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ARTICLES

THE CONDITIONS OF INCREASED PRODUCTIVITY IN AGRICULTURE

By KEITH O. CAMPBELL

Introduction

Australia today faces the urgent necessity to step up agricultural production at a comparatively rapid rate. The Government's 1952 production objectives envisage that by the 1957-58 season, production will be increased by 20 per cent. over average production in recent years or 28 per cent. over prewar production.

In a relatively advanced agricultural economy such as the Australian, it is to be anticipated that such increase in output as is achieved will come primarily from the application of new technological advances to farming and the consequent raising of productivity per worker rather that through the employment of more land and labour in agriculture. Indeed, the universal trend in such an economy is for the relative size of the labour force in agriculture to decline over time.

The rate of rise in Australian agricultural productivity since 1939 gives no grounds for complacency as to the speed at which new technology is being incorporated in farming practice in this country. Clark (1950) has stated that in Australia, United States and other advanced agricultural communities, the application to agriculture of new scientific techniques and new mechanical aids alone, can be expected, on past experience, to raise output more than 2 per cent. per annum. That is, a rise in output of this magnitude will normally occur through time if the land area and labour force are held constant.

The increases in aggregate output achieved since the beginning of World War II in Australia, Canada and the United States are indicated in Table I. Estimates of the compound rate of increase in productivity per worker per annum over this period are calculated from data for the two latest years for which information is available. It will be noted that the agricultural labour force has declined in all three countries.

In Australia the rate of increase in productivity per worker falls far short of the 2 per cent. rate, while in both Canada and the United States the rate of increase is well above this level. Moreover, Australia had achieved a 9 per cent. increase on prewar output by the 1947-48 season, and since then production has stabilised about that level. Correspondingly, there has been virtually no increase in productivity per worker in the past five years, such increase as has occurred having taken place before 1947-48.

These facts suggest that in the past fifteen years, advances in biological and engineering sciences have not been incorporated in Australian farming practice at the customary rate, nor at the rate attained by other countries in a comparable state of agricultural development. The relatively slow rate of rise in productivity

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should be disquieting for anyone connected with agricultural research and extension in this country.

In these circumstances, it is appropriate to consider the mechanics of incorporating new and improved techniques in farming, and to analyse the conditions which must be satisfied, if this process is to be facilitated. This paper is a contribution to that end.

Distribution of the benefits of technical progress

Many false ideas about the assimilation of new agricultural techniques can be traced to a mistaken identification of the principal beneficiaries of technical progress in agriculture. We might therefore begin by briefly examining the typical pattern of distribution of the benefits of rising productivity in agriculture.

It is now about 225 years since Jonathan Swift sagely observed that "whoever could make two ears of corn or two blades of grass to grow upon a spot of ground where only one grew before, would deserve better of mankind and do more essential service to his country than the whole race of politicians put together". Swift, though not an economist, was correct in stressing the benefits which the entire community reaps from technical advances in agriculture. However, modern writers on the subject are wont to give the impression that scientific research primarily assists farmers by increasing their net incomes. Indeed, such an argument is used effectively to justify the large sums spent by governments throughout the world on agricultural research and extension. This modern-day contention nevertheless is a fallacy.

Generally speaking, the benefits which flow from the introduction of new techniques in agriculture do not accrue to the farmer (Heady, 1949). Looking back over recent historic time when new technologies have been passing out to the farming community at an increasing rate, it is difficult, if not impossible, to demonstrate that, as a consequence, the income position of farmers has improved relative to the rest of the community. Though

TABLE I

Index Numbers of Farm Output, Rural Work Force, and Productivity per Worker for Australia, Canada and the United States.
(*Base*: *Average 1935-39 = 100*)

Country	Year	Farm Output	Rural Work Force	Productivity per Worker	Compound Rate of Increase in Productivity per annum
United States	1951	139	86	162	3.5
	1952	141	84	168	3.5
Canada	1950-51	136	76	179	4.2
	1951-52	147	73	201	4.7
Australia	1950-51	110	91	121	1.4
	1951-52	102	89	115	0.9

Sources:

U.S. Department of Agriculture, *Agricultural Outlook Charts.*
Commonwealth Bureau of Census and Statistics, *Production Bulletin.*
F.A.O., *Yearbook; Canada Yearbook.*

there are many other factors bearing on the relative income situation of farmers, the basic reason for this state of affairs is that the demand for most agricultural products is inelastic. This means that the increase in output which, in most cases, flows from a new technology in a particular industry, causes the price of the product to fall to such an extent that a lower total revenue is received from the sale of the product than was obtained when output was less. Reinforcing this tendency towards lower incomes is the fact that almost invariably innovations involve greater money outlays, even though costs per unit are lower.

In short, the extent to which producers in an industry are likely to benefit from a new technique, depends on the effect of the technique on total output, its effect on costs, and the elasticity of demand for the product. On these criteria, the typical biological innovation which is output-increasing and cost-increasing, is doomed as a money-spinner for an agricultural industry before it is ever adopted.

Other situations where prospects are brighter could be postulated, e.g., where the output does not increase or where the demand for the product is elastic, but practical examples of this type of innovation are rare. Mechanical innovations, which do not result in increased output but which involve lower total costs, alone offer clear prospects of increasing the net income of an industry. More often than not farmers do not reap the full benefit of lower costs flowing from the introduction of new machines because they cannot, or do not choose to, carry through the organizational implications of the change —for instance they do not release the labour set free during part of the year by adoption of improved mechanical equipment.

On occasions farmers, by collective action, can emulate labour and industrial management in retaining the gains achieved from increased productivity. Johnson (1952), in a study of the burley tobacco industry of the United States from 1933 to 1950, has concluded that the control programmes in operation in that industry have retained for the benefit of producers the income derivable from the increased productive efficiency. However, this industry has peculiar attributes, which could be duplicated in few agricultural industries, and which are primarily responsible for the occurrence of this rather exceptional result.

If the farming community does not usually benefit from scientific research in agriculture, who does? Clearly the chief beneficiaries are the consumers, who are enabled to purchase increased amounts of food at the same price and the same amount of food at a lower price. In short, the population as a whole benefits from the improved purchasing power which technological progress makes possible, whether it takes place in agriculture or other industries. The farmer, as a member of the general community, is equally a gainer in this indirect sense.

The foregoing conclusions apply with particular force to the introduction of new techniques in the production of commodities destined wholly or almost wholly for the domestic market. Almost invariably the demand for these commodities is inelastic. It is possible, however, that rising population and/or rising real incomes may cause the demand for foods to increase at a sufficiently rapid rate over time so as to offset somewhat the income-reducing properties of new farm technology.

When new techniques are applied in export industries, farmers may gain a little more than in the case just discussed, because the demand on the export markets tends to be more elastic than on the domestic market. The elasticity of overseas demand depends largely on the proportion of world trade in the particular commodity which the shipments of the exporting country represent. If the proportion is high, conditions analogous to those which occur in the domestic market are likely to arise. If the proportion is

low, demand may be relatively elastic. Again, other factors such as the existence of a dollar shortage, may mean that some export producers, in the short run, could benefit more than they would under more normal circumstances.

Inasmuch as the adoption of new techniques raises the productivity of Australian farmers and this, in turn, leads to an increase in the export income for this country with the same amount of labour in the export industries, then the standard of living in this country is destined to rise, because of the increased command over imports thus afforded.

Publicly-financed research in agricultural industries, which is made necessary by the small-scale nature of the typical agricultural firm and its consequent inability to sink funds in developmental research, should therefore not generally be regarded as a disbursement for the benefit of the agricultural industries concerned, but rather as an investment from which the entire community draws benefits. This being so, the efforts being made recently to encourage, or even coerce, agricultural industry groups, marketing boards and the like, to finance research into the problems of their industries, are rather unjustifiable. At the same time, considering the widespread benefits which come from technical progress, it would be sound economics, as Schultz (1953) has demonstrated, for most governments to make much larger investments in agricultural research than they are currently making.

The effect of technical progress on the individual farmer

Having examined the overall effect of a particular innovation on an agricultural industry as a whole, let us look at the picture from the standpoint of the individual farmer at various stages in the process of assimilating a new technique. We can now appreciate how it comes about that the extent to which an individual farmer is likely to benefit from a specific practice is dependent on the particular point in time at which he adopts the new practice.

There is ample evidence to indicate that the adoption of new techniques in agriculture follows the general sigmoid pattern which is typical of the diffusion of most types of cultural change. There is first a long period of slow initial extension of the practice, then a rapid rise in the rate of adoption by farmers, and finally, a period when the more conservative farmers gradually adopt the technique.

From an economic viewpoint, those who are leaders in the adoption of a new practice are likely to reap some monetary reward in the form of higher incomes. This is because the extra amount of production turned out is not sufficiently large to affect significantly the aggregate demand for the product of the industry, and hence the price of the product. These people can therefore sell their increased output at the old price. This initial income advantage is likely to decline rapidly as more and more farmers adopt the practice in question, until, ultimately, in the typical case, there is no monetary gain accruing to producers who introduce the particular practice into their farm organization. Those conservative individuals who have not adopted the practice by this time, will usually find their income getting progressively less and less in line with the decline of prices. They will be in the position where they are forced to adopt the new technique to make an income sufficient to live on, even though that income may be less than that to which they were accustomed before the innovation came into existence. This is the only sense in which any monetary advantage is likely to accrue to the more conservative or dilatory farmers adopting a practice long after their more enterprising neighbours. If the income gained by such farmers is insufficient to meet the individual farmer's needs, or if he is unable to adopt the innovations because of the size of his farm or lack of capital, his only alternative is to get out into some

other occupation. It is by such a process that the number of farm operators in a progressive economy gradually becomes smaller.

The provision of information

The first and most elementary requirement, that must be met before a new technique can be incorporated in farming practice is that farmers should be aware of its existence. The dissemination of information about new scientific and mechanical advances in agriculture is generally accepted as the major responsibility of any extension service.

However, the exact function of the extension worker is too narrowly defined. It is too often assumed that the lure of increased profits can be depended upon to lead to the farmer's adoption of a particular practice as soon as information about that practice is disseminated. Consequently, most of the effort in extension work tends to be dissipated in providing information. We have already seen that the notion that farmers generally derive great benefit from technological progress is not based on fact.

Dissemination of information is actually only one small facet of the process of getting new scientific discoveries into farming practice. There is a world of difference between bringing a new technique to a farmer's attention and his adoption of that technique on his farm. Ryan and Gross (1950) in a study of the process of diffusion of the use of hybrid maize in Iowa (an unusually simple technique, the adoption of which is associated with a minimum of complications), showed that there was an average lag of 5.5 years between the time farm operators first received information on hybrid maize and the time they adopted it. For those who adopted the new technique early the lag averaged 1.6 years, while for those who adopted it very late the lag averaged 9.2 years.

This type of statistical evidence should act as a deterrent to those who would glibly explain the failure of farmers to adopt certain practices in terms of their ignorance of the techniques in question. It should also help to keep in perspective ideas about the extent to which agricultural production can be raised merely through an expansion of informational services.

The Iowa study and others of its type raise some question as to the degree to which the publicly-sponsored extension service is, in fact, directly responsible either for bringing information to the farmer, or, more important, for influencing him to act on the information.

In the hybrid maize study, farmers were asked what agencies they considered to be most important in influencing them to adopt hybrid seed. Of the farmers interviewed, 49 per cent. named salesmen as their original source of knowledge concerning this new technique. Other commercial sources such as radio advertising and farm journals were each given pride of place by 10 per cent. of farmers. Neighbours and relatives brought the news to 18 per cent. more and the extension service was the first to inform 1.8 per cent. of the farmers.

When asked what agencies were influential in their eventual adoption of hybrid maize (as distinct from knowledge of the existence of hybrid maize), 46 per cent. pointed to their neighbours and 32 per cent. felt their judgment was influenced most significantly by salesmen. Other influences played a relatively minor role, the extension service being credited as a major influence by 2.4 per cent. of the farmers interviewed. Very similar results were obtained in a recent statewide survey in Iowa, in which farmers were questioned on their sources of information about the use of antibiotics in animal feeding. These experiences could undoubtedly be duplicated in New South Wales, for example, in connection with the weedicidal control of skeleton weed.

It would appear, further, that the relative importance of the various influences

affecting the farmer changes with the passage of years after the introduction of the new technique and also with the type of technique in question. Data of this type need to be interpreted with caution. But, even taking account of the influence of the extension service on other agencies disseminating information, the results of such surveys nevertheless do point towards the role of the extension service in getting farmers to adopt new practices as being a relatively minor one, even in the United States, where the personnel and resources committed to this enterprise greatly exceed our own.

Raising the economic content of extension information

Considerable support has been demonstrated recently for the argument that the current lag between research and practice could be reduced markedly and the extension process greatly facilitated, if more attention were devoted to working out the economics of particular farm practices. Farmers, it is said, would be much more ready to adopt a new technique if, at the time of their first introduction to the technique, they could be told what it would cost, and what profit could be anticipated.

This approach is somewhat more sophisticated than that of those who foresee great advances in agricultural productivity springing merely from the provision of expanded information services. It does recognise that there are economic elements in the situation which affect farmers' decisions whether or not to adopt a new technique. But it is still rather inadequate.

In the first place, considerable lags occur in the adoption of new techniques even when the economic advantages offered are clearcut. To refer to the hybrid maize example once again, it requires no profound economic analysis to demonstrate that the early adopter of this practice would reap returns far in excess of the additional costs incurred. Yet, in the Iowa study, for the first 37 per cent. who adopted the practice, the average delay between first hearing and eventual adoption of the practice was 3.7 years. Hybrid maize is, by no means, unique with respect to its obvious economic advantages. Many of the production innovations of recent years, as Wilcox (1951) has pointed out, are cost-reducing to the extent that they are profitable under any level of product prices which permits the producer to stay in business.

Second, the natural scientist should hesitate to blame the economist for the inadequacy of extension information when so much of the production data turned out by natural scientists is unsuitable for the economist to use for costing purposes. To illustrate, let us take a relatively simple case—the application of fertilizer. It is rare indeed that the agronomist establishes the physical relation between rates of application of fertilizer and corresponding outputs of production over a sufficiently wide range of applications to enable the nature of the production function to be established. Quite often the agronomist ceases his experiments at a rate far below the most economic rate of application. To my knowledge, no fertilizer experiments in New South Wales have ever met these elementary requirements. Without information of this kind, any advice on the economics of fertilizer application is ill-founded. These shortcomings are not, however, unique to this country (Fellows, 1950; Nesius, 1950; Paschal, 1952).

Thirdly, it must be recognised that the farmer operates in a dynamic environment, in which all the economic variables are in a constant state of flux. In making a particular production decision, he must act according to his best estimates as to the costs, prices and other variables which are likely to prevail in the immediate future. Often under Australian conditions he even has to formulate estimates as to the nature of production functions likely to operate in the ensuing season.

These procedures apply as much to the adoption of new practices as to any other managerial decisions. The weedicidal action of 2,4-D on skeleton weed may be immutable and established for all time, but the profitability of this practice certainly is not. In short, the economics of adopting a particular technique established at a point of time cannot be expected to remain valid for any extended period.

Finally, and most important of all, the economic aspects of the adoption of any new technology must be worked out in terms of the individual farm. It is of little value to a farmer contemplating the adoption of a new practice to have some hypothetical cost information or even actual cost information secured from Bill Jones' farm, whether Bill Jones' farm be ten miles away or next door. The farmer needs rather to appraise the economics of the proposed change in terms of his own situation—the size and age distribution of his labour force, his cash reserves, his credit status, the area of his farm and so on. More likely than not, the farmer will find that on his farm even the physical relationships existing, for example, between the application of different rates of fertilizer and the resultant yields, are quite different to those established on experiment farms or demonstration plots. These differences are likely to be more pronounced when more complex resource relationships, such as arise with machinery, are involved. The vital information needed for the individual farmer's planning is the production feasible on his farm, given the resource limitations—physical, economic and personal—not the production possible under experiment station conditions or on somebody else's farm.

This does not mean that a farm management expert or suitably trained extension worker cannot assist the farmer to work through the implications of new techniques for the economic organization of his farm. This sort of job should have top priority in any extension service, for it is a service which no other agency, with the exception of a professional management service, can discharge effectively. Nevertheless, the considerations outlined above do cause one to question the universality of conclusions drawn from generalised studies of the profitability of new farm practices and hence to doubt whether more studies of this kind would help to speed the adoption of these practices.

Impediments to the adoption of new technology on the individual farm

Acceptance of the fact that the problem of economic organization is largely unique to each farm is fundamental to any realistic approach to the job of getting new techniques incorporated in agricultural practice. It is the personal resource limitations of the individual farmers which go much further towards explaining their failure to adopt new methods than lack of knowledge of any particular practice.

Up to this point, emphasis has been placed on the uniqueness of the set of resources available to the farmer. But the forces impeding the adoption of new practices at the farm level are not purely economic in nature. Each farm operator has his own ends which he desires to maximize. He may desire to maximize net income within certain limits but, on the other hand, he may simply have a strong desire to own and operate a particular type of machine. Each operator has his own peculiar personal attributes, and his own set of attitudes and prejudices, conditioned by past experience and the cultural environment in which he lives. He is motivated by a considerable number of influences, which could not be considered economic by any stretch of the imagination.

Just how strongly these psychological and sociological factors can operate in resistance to change, whether narrowly technological or not, is not generally appreciated. We do gain some insights

from a study like the Iowa study on adoption of hybrid maize. Similar studies conducted in this country could provide valuable insights on the reaction of our farmers to technical changes of various types.

The problem in human relations presented by the complex of individual differences existing between farmers is often completely overlooked. Too often is extension work viewed as a technical problem rather than a social and personal problem. As Hardin (1951) has remarked in another context, agriculturalists are too often concerned with getting new techniques adopted on the *land* and too infrequently with getting *people* to adopt these techniques.

The neglect of the human element in the traditional approach to agricultural extension is perhaps no better illustrated than by a comparison of the reports of the two committees appointed at the British Commonwealth Scientific Conference (1952) to consider the application of results of research in industry and agriculture respectively. The Industrial Committee emphasised the importance of the human factor in all aspects of the application of science to industry. The report of the Agricultural Committee, in contrast, is almost exclusively given over to a discussion of the technical qualifications of extension workers and the maintenance of adequate liaison with research workers.

The narrowness of the prevailing conceptions of what is involved in getting research results into practice necessarily affects the standards set for personnel in the extension field. Emphasis in the past has been placed on technical and forensic ability. The foregoing discussion suggests that a broader background is desirable. If extension workers are to do an effective job, then in addition to agricultural skills and suitable personality traits, they need a thorough knowledge of the economics of management of the individual farm, an appreciation of the broader economic and social environment of which the farming community is part, and a thorough understanding of social psychology.

Adequate supplies of production requisites

A second primary condition which must be satisfied before farmers can be expected to put their knowledge to good use is adequate supplies of the materials necessary to the improved methods advocated—whether these be hybrid seed, superphosphate or tractors. Generally speaking, supplies of such requisites quickly become available in response to demand in normal circumstances.

In a semi-controlled economy, problems of inadequate physical resources in agriculture are apt to arise. We have had some experience of this kind in Australia in recent times. The easing of many of the shortages consequent on the lessening of inflationary pressure in the past nine months suggests that they arose primarily from the existence of severe inflation.

In a properly functioning economic order the possibility of shortages of production materials on farms would not even be seriously considered as an impediment to increased productivity arising from technical progress. Even in the Australian case, much more has been made of these shortages as an explanation of the slow rise in productivity than the facts merit.

Increasing capital requirements

The third factor which appears to condition importantly the adoption of new agricultural techniques is the availability of cash or credit for investment. The nature of technical progress itself tends to accentuate this problem as time goes on. Increased farm mechanization raises quite dramatically the capital investment required per farm. The fact that the farm operator, working with more power

and equipment, can handle larger acreages, means economic pressure to enlarge the size of farms and to increase the investment in land. Even so, the tendency is for investment in assets other than land to increase relative to investment in land (Schultz, 1951).

In addition, biological as well as mechanical innovations are making ever-increasing demands on the cash reserves of the farmer or, alternatively, increasing his need for short-term production credit. Recent American experience points towards farm production expenses rising faster even than the value of physical farm assets. The modern farmer has to purchase fuel and oil for his machinery instead of raising feed for his horses, he purchases hybrid seed whereas formerly he probably saved his own, he is purchasing fertilizer in quantities far in excess of what he purchased a decade ago, and he is purchasing new chemicals for uses he never contemplated a few years ago. This upward trend in requirements of operating capital means a further need for financial reserves to withstand the shock of farm income declines whether these declines arise from drought or a price recession.

These increasing capital demands of modern agricultural practice raise problems for the farm operator who is genuinely interested in increasing productivity. Given a banking system which is traditionally cautious in the matter of agricultural credit, any government concerned with stepping up agricultural production has also cause for concern.

Recent reports emanating from the Department of Commerce and Agriculture (1952) have indicated the extent to which this country has lagged in the years since the war as regards investment in mechanical equipment alone. The depleted stock of obsolete working equipment intensifies the need for investment capital in the immediate future if lost ground is to be regained.

The current obsolete condition of much of the capital equipment on Australian farms has serious implications for Australia as an agricultural exporter. Maintenance of competitive advantage *vis-a-vis* other countries is largely dependent, in the modern world, on continued ability to exploit new inventions and new techniques. Sufficient capital must be channelled into agriculture to make such exploitation possible.

The problem appears in an even more acute form in connection with the financing of those who are just beginning as farmers whether on private account or as participants in governmentally-sponsored land settlement schemes. For persons contemplating the acquisition of grazing and wheatgrowing properties in New South Wales a minimum capital requirement of £20,000 to £25,000 is currently necessary. Figures of this order are beyond what the average farmer can be expected to save in a lifetime. The capital requirements of an efficient farm unit also raise problems at the Treasury when it comes to financing large-scale land settlement operations. Quite apart from the financial angle, there is the politico-ethical question whether a community should make capital advances of this order to a chosen few, even though selection is completely random, subject to the participants in ballots meeting minimal qualifications.

Parallel with the long-run trend towards increasing capital requirements in agriculture, there is a distinct possibility that the traditional source of investment funds in agriculture, namely, farmers' savings, may shrink over time or at least prove progressively more inadequate than in the past. One cause of possible shrinkage may arise from the increasing acceptance of price stabilisation schemes, which tend to eliminate the occasional boom conditions, which in time past have afforded the main opportunity for saving in agriculture. Recent changes in taxation policy have probably also adversely af-

fected the volume of farmers' savings. To the extent that farmers' savings do prove inadequate, we may be forced to explore the possibility of making special tax concessions to primary producers in order to increase the amounts available to them for investment. The special depreciation allowances introduced last year, though designed with other objectives in view, may also be a portent of permanent concessions in the future,

An alternative way of meeting the increasing capital demands of modern farming lies in the development of new institutional means of transferring capital from other sectors of the economy into agriculture. Such movement has not been very facile in the past. One method by which such a transfer might be achieved might be the expansion of the corporate form of enterprise in the rural areas. This was the solution developed in the industrial sphere 150 years ago when a similar problem arose there. The expansion of tenancy in agriculture as a means for gaining control over capital assets provides yet another method. Credit institutions could also play an important role in facilitating the flow of capital to agriculture. A pointer in this direction is given in the last annual report of the Rural Bank of New South Wales (1952), in which there is a plea to "other non-primary sectors of the economy to strive to become more liquid in their accounts and so leave the banking system as a whole free to extend its resources to the utmost to support the nation's food producers".

It should be recognised that even if better credit facilities for agriculture are provided, the unwillingness of the farm operator to borrow may prove a major impediment to rapid improvement in farm techniques. A recent study in Iowa by Heady and Swanson (1952) gives some indication of the kind of problem presented by the great reluctance of many farmers to use credit. This study indicates that in the area investigated more than 50 per cent. of farmers would not borrow money unless the probable rate of return was 25 per cent. or higher and nearly one-sixth would not borrow in any event. The remaining one-third indicated a willingness to borrow if a return of about 10 per cent. or more could be realised. In the Australian scene, it would not be at all surprising if the requirements of farmers as regards a minimum return on borrowed money were even higher than those revealed in the Iowa study, because of the greater production uncertainty associated with farming operations in many parts of this country.

The role of government in facilitating technical advances

In conclusion, the question might well be asked, what role can government play in facilitating greater productivity in agriculture? There are, of course, very limited ways by which any government can affect directly the production decisions of entrepreneurs in a sector of the economy where private enterprise is dominant. There are people, such as Bennett (1947), who despair of rapid improvement in productivity under traditional types of farm organization, and foresee direct participation by government in management. But such prophetic visions do not savour of political reality, at least in Australia.

Governments can and do provide special services to agriculture in the form of socialised research, as well as extension services to bring to farmers' attention the results of such research. Expansion in research activities would pay any government handsome dividends. The same applies to expenditure on extension, provided there is greater realism as to the nature of the job to be done. Farmers' knowledge of new techniques is a necessary condition for improved efficiency, but it is by no means a sufficient condition. The social and economic aspects of the application of new knowledge and skills to farming are probably more im-

portant and certainly more intractable than the technical and educational ones.

Except under extraordinary economic conditions, governments should not have to be concerned with direct *ad hoc* action to ensure the adequacy of materials required to increase productivity in agriculture. The main influence which governments can exercise on agriculture or any other industry in a similar position, is exercised through price policy, credit policy, tariffs and similar broad economic controls. Wider recognition of this fact would do much to correct the false impression that action by state governments can affect agricultural production significantly, even though, constitutionally, this is their responsibility.

While new discoveries of agricultural significance may be forthcoming at a fairly uniform rate, the impact of these discoveries on farm production has characteristically in the past been rather intermittent. It is clear that these discontinuous spurts in the adoption of new techniques are associated with favourable demand conditions for agricultural products. At such times, farm prices and incomes tend to be rising and farmers formulate favourable income expectations. Their own liquid funds tend to increase, they are prepared to use these and to seek bank credit to invest in new technological methods. In short, the problem of increasing productivity is becoming more and more a problem of the farmers' securing control of funds for additional investment after he is satisfied that the future outlook is such as to justify that investment. This fact has not been sufficiently appreciated in this country (Campbell, 1952).

The policy implications of the foregoing are obvious. If a government desires to lift productivity, special attention needs to be given, first to those elements of economic policy which affect the ability of farmers to acquire liquid reserves as a basis for investment, such as price and taxation policy; second, to those elements which affect farmers' ability to finance new investment, such as bank advance policy; and third, to the complex of influences which affect farmers' expectations as to the future.

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AGRICULTURAL ENGINEERING

By G. H. VASEY

III.

OPPORTUNITIES IN AUSTRALIA

A FEW WELL-KNOWN FACTS ASSEMBLED

Number one

The annual value of Australian primary production is around £1,000 million. The whole of this production goes through either machines or buildings or both, on the farms and stations of our countryside. Exclude the fat lambs, if you like, and some of the fat cattle, if you insist—the point remains unchanged, namely, that this production effort inevitably involves the farmer in tractors and machinery, buildings and equipment, water supply and plumbing, drainage and soil erosion. The farmer cannot escape these mechanical things; and he no longer wants to; he finds he cannot do without them, and is beginning to build his machinery and equipment firmly into his farm management and policy.

Can anyone say that the equipment required for this substantial production, and the use of it, present no problems in research, and no problems of education, advice and "extension" among the users of it? Are we to suppose that the designs are universally above reproach, that nothing now remains to be done to suit our machines and tractors to the soil, to the crop, to the climate and to the farmer?

Can we assume that our field techniques are likewise above reproach, that our routine jobs and chores are efficiently done, that our fences and buildings, and drains and water supplies are well laid out, where they ought to be, and of an adequate size and capacity to meet their functional demands?

How marvellous if all these things were so! It is not so in other parts of the world, even in the U.S.A. Dare we assume there is no problem in Australia?

Number two

In the field of biology, economics, and agricultural science generally, authorities all over the world know that farmers cannot solve or even tackle the industry's many pressing problems. We see this clearly enough in Australia; else why CSIRO and the State Departments of Agriculture? That is to say the need for research and extension in the obvious fields of agriculture is admitted as a proper responsibility of the people on behalf of the primary industries.

Number three

In the field of mechanical and capital equipment, farmers as a class are not as well informed or advised as managers and proprietors in other industries. Farmers are not well equipped to lay down specifications of what the individual farmer wants in the way of machinery and equipment; and they are singularly ill-equipped to conduct their own tests or investigations into the performance of their tractors, machinery, and equipment and buildings.

A farmer may indeed be satisfied with his choice of equipment and methods, or justifiably critical; but he has little

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chance of detecting or measuring the hidden losses or the inefficiency, or of raising his standard of performance by heaving on his own shoestrings.

Number four

In spite of these facts of life there is no significant research in Australia into the problems of field machinery or the mechanical equipment; or the farm buildings or the water supply; or into anything that looks, sounds, or smells like farm mechanics, farm mechanisation, or agricultural engineering.

Yet according to item number one, the buildings and fences, machinery and equipment, tractors and motors are as much a part of modern industrial agriculture as the soil, the crop, the climate and the farmer himself.

Number five

In Australia there is no service or system of extension on the mechanical side of agriculture, neither in farm mechanics, nor farm mechanisation, nor, of course, in any other phase of agricultural engineering. How can there be, when there are no officers trained for the work, when departments do not see the need of it, and when there is no body of knowledge to carry into the field.

Yet it is a fact that some farmers and groups of farmers are beginning to show a lively interest in the lack of such an extension service, and in what they can profitably (and pleasantly) learn from discussions of these matters with engineers.

Number six

(a) There is some teaching of farm mechanics, and farm mechanisation in the agricultural colleges (characterised in one college at least, by giving lesson number one on "How to harness a horse"). But are the colleges staffed by engineers, or even deputy assistant engineers, for this purpose?

(b) There is some teaching of farm mechanisation including a description of engines, tractors, and machines and how to use them, in the courses at most, if not all, the Australian universities where agriculture is taught.

(c) There is in Australia no teaching of agriculture to engineering students; there is no way for an engineer to acquire any professional instruction in the applications of engineering to agriculture; or to acquire any recognition as "an agricultural engineer", except by getting orthodox professional recognition in both fields.

Number seven

In short, the term agricultural engineering has no content and no meaning in Australia. This is surely odd, both in comparison with ourselves (item number one), and in comparison with agriculture in other countries.

Yet, there are many useful things that could be done in Australia if we so had the mind. Some things may be small, perhaps even trivial; others may be large, requiring big efforts. Whatever is done, small or large, will require big decisions, real changes of mind, to start them. The basic change of attitude at all levels is in recognising that mechanisation, and the use of mechanical and other capital equipment, are necessarily an integral part of Australian agriculture, not merely an adjunct, a recent introduction, an innovation, or a nice, but not quite vital, idea.

Samples of the practical things that could be done, if we had this basic attitude, are mentioned and discussed below.

OPPORTUNITIES IN AUSTRALIA

Research

When the Advisory Council for Science and Industry began in 1916, no one then could have named or even imagined the great list of tasks that have since been undertaken by its successors CSIR and now CSIRO. We all know the story of the frontiers of ignorance—we never reach them. As the work goes on, the jobs open out—solving one problem only to pose *n* more. That happens even with

routine testing, if the testing authority's mind and terms of reference are open to see and follow the clues.

So we could name a dozen or so items of agricultural engineering fit for immediate study; in ten years' time the list will be twice as long; or three times—who knows?

Here, for example, is a list recently prepared by the AIAS Victorian Branch Subcommittee on Agricultural Engineering—the shortest and most useful document that the Institute has put out in all its rambling and uncertain discussions on this theme:—

1. Investigations in field performance and power consumption of various field implements.
2. Study of fodder handling methods, applicable to the conditions peculiar to Australia.
3. Economic handling of grain on the farm and between the farm and the bulk terminal.
4. Engineering aspects of economic fodder conservation.
5. Functional design of buildings, storages and feeding devices.
6. The studies of structural materials and methods for buildings.
7. Study of farm dwellings and their improvement.
8. Engineering aspects of irrigation and drainage.
9. Fundamental investigations in tillage and traction.

(1) A central group

To attack these and similar problems seriously would take a team of perhaps a dozen or so men, something not too big to start with.

The workers should be mainly engineers, but there must be close touch with agricultural teams and a statistical group. The team must have its own equipment, and have access to a workshop, and to the field or field stations. Interested people may enjoy the mental exercise of working out where such a group might be centred, and what parent body is ever likely to adopt it, provide it with financial sustenance, and give it strength and scope in which to grow.

For the sake of developing an argument let us suppose a research group were to be set up; and let us further suppose that its terms of reference excluded teaching and extension from the group's activities. The following discussion, though developed on such a basis, can be modified in detail to suit the consequences of a different premise.

(2) The Universities

There will always be scope in this field for a steady small stream of research in the universities. The universities would suffer no great harm to their ideals if the faculties of engineering and agriculture were to come together in such work.

The phases that so well suit these small teams are:—

(a) field surveys of the status of mechanisation and mechanical equipment on farms, in certain areas or in certain primary industries, or both;

(b) field studies of mechanisation practices, including, for example, typical case studies of certain techniques or machines;

(c) field studies of farmers' attitudes towards the machinery, and towards the need or value of extension services on the mechanical, or engineering side.

Such studies will obviously be relevant to any teaching the universities may conduct, and to the research centre in revealing useful lines of enquiry, and to the extension system if any, in suggesting where help is most needed.

Naming these suggested lines of enquiry does not imply that university groups, if any, should not follow their natural bents in any sensible direction.

(3) The Agricultural Colleges

These are ideal centres for mild doses of field investigation (we must not defile the word "research"), if not into the higher flights of engineering, at any rate into some of the local problems of machine/soil/crop performance; the study of techniques and routines; case studies, field surveys, and so on. There is ample scope for co-operation between the college groups and those at the universities and the central group.

Such a move as this would be one way of stimulating in the colleges a modern approach to mechanical agriculture.

Extension

By custom and by explicit agreement, extension in agriculture in Australia is the province of the State Departments of Agriculture. If, then, there is to be effective extension on the equipment side, this work must necessarily be built into the state extension systems.

For our guidance we have the American pattern of having a team of agricultural engineering specialists at the state centre, available to all the agricultural field officers, or the English and Swedish pattern of having machinery advisory officers located in the districts.

To suggest details now would not be sensible, but the principles ought to be clear:—

(1) A proportion of the specialist officers, if not all of them, should be agricultural engineers—either technical school diplomates or university graduates.

(2) The organisation must be spread or condensed, or split into wide districts, so as to give the farmers and/or the field agricultural officers ready access to the engineering advice.

(3) The agricultural engineering officers will be advisers and instructors, not itinerant mechanics carrying a kit of tools. They will be concerned with demonstrations and tractor and maintenance schools, with extension groups and clubs, including Young Farmers. They will, we trust, be competent to get underneath things, and soil their hands, but it will not be their job to do the repairs that Farmer Gyles wants done. There is no conflict with the implement firms at this or any other point.

(4) This field of activity should not be confined to implements, machines and tractors—mechanisation in its narrow sense. It will be found that farmers will need and will welcome advice in other practical matters, especially buildings, domestic mechanics, chore routines, irrigation, drainage, soil erosion and water supply. The system, then, to be effective should contain also officers trained to cope with these problems.

(5) There must inevitably be close liaison between the extension teams and the various centres of research. If there is a major research centre, we know that literature is the chief medium of exchange; but other points of contact can be arranged. If research is also carried on, even in a small way, at the universities and colleges, there you have an excellent medium for interpreting the major research programmes, and of leavening both the research and the extension teams.

Teaching

Here we are thinking of all three notions: farm mechanics, farm mechanisation, and agricultural engineering. Consequently teaching in these fields must be offered at a variety of levels. The possible avenues are the high schools, the agricultural colleges, the technical schools, and the universities.

(1) High Schools

People are continually becoming distressed about this "awful drift from the land". There are many reasons why the "drift" is inevitable, if not proper (unless

we are to have a peasant agriculture). Nevertheless it would be wise to offer school boys some interest in the country life, and some enticement to stay in it, if they so desire.

One way of doing this is to teach some farm mechanics in the larger country schools. Think of the interest that would be created in classes and workshop practice on engines, gear boxes, and tractors. The equipment back home on the farm would begin to take on more meaning and attraction. The next step for many boys would be the agricultural college, and then the farm life at home, with a lively understanding of the mechanical side of it.

I suggest the time has come to put this sort of interest alongside (dare we say in place of?) the traditional love of the horse, which has for so long been the basis of many farmers' farming.

(2) Agricultural Colleges

Both Farm Mechanics and Farm Mechanisation are obviously a part of the curriculum in what are, in effect, agricultural technical colleges. A survey of the colleges in Australia to assess the adequacy of the equipment, the content of the courses, and the quality of the teaching, would, to say the least of it, be informative. A resentable proposal, no doubt, but overdue, and no more scandalous than the AIAS surveys of university degree courses.

There may be room for discussion about how far instruction in farm mechanics should go: we aim at turning out farmers, not A-grade mechanics. But instruction in the principles of the machines and tractors, and especially the principles of mechanisation, should be taken as far as the students, the equipment and the staff can go. Until the staffs contain some professional engineers, these courses are not likely to go as far or as well as they should. As I said earlier, to keep these technical staffs lively they should be encouraged to take up local investigations or research in this field.

(3) Technical Schools

The place of a country town technical school in its local community is unreal unless its curriculum impinges in some way on the local agriculture. One way of doing this is to offer trade courses in farm mechanics, and possibly diploma courses in engineering with a bias towards agriculture. This latter group could, for example, provide the technical salesman for the firms selling farm equipment; such men would be more acceptable to the farming community than the so-called "city slickers" or the men who have had no technical training.

(4) The Universities (a) Mechanised Agriculture

Even though our courses in agricultural science are aimed at science rather than farming or farm practice, some respect is due to that part of the science known as mechanised agriculture.

For effective teaching in it one may wonder whether it is better in the hands of an engineer who can cope with the technicalities and the principles behind them (though these are admittedly relatively simply told), or whether it is better in the hands of an agriculturalist. It might well depend on whose mind runs the risk of being less progressive—the agricultural scientist who ought to want more things done better mechanically, or the engineer who has to see how these things could be done. This is a clear case for the notion of an agricultural engineer—one who can balance both points of view.

If we are to lift the study of this part of agriculture out of the status of a handy adjunct, and integrate it fully into the understanding of farm management, then research should accompany the teaching. This will usually mean engineering research, and so will require engineers to do both the research and the teaching; again this points to the need for agricultural engineers.

(*b*) *Degree Course in Agricultural Engineering*

Of all the items in this list of possibilities, this—the last, and the least as an end in itself—is the question that received most attention from the various committees, sub-committees, and counter committees of the AIAS over the last three or four years. The resolutions about it were half-hearted, the approaches to universities were abortive, all interest evaporated, because it was realised that, on the most optimistic estimates, we could only invent three or four jobs a year for the prospective graduate agricultural engineers.

Let the AIAS support some of the activities mentioned in these notes—or think of other and better ones—activities that require the services of agricultural engineers; then the need will appear for some kind of formal training to meet the situation. If indeed the situation were to develop along these lines, or even along some of them, especially in the direction of research, the demand for adequate graduates will be a growing one; that is the sort of situation that the universities may be more willing to meet.

So let us stop urging degree courses in agricultural engineering; they are not wanted; they will come in due course once the inevitability of agricultural engineering is generally recognised.

While allowing the degree courses to wait on other moves, we should remember two or three principles:—

(1) Agricultural engineering will be engineering, but the faculty of agriculture must be involved as a partner, in curriculum and management. If there is none of the daily contact associated with having both faculties on the campus, then such a proposal and such a course will be unreal.

(2) It is unlikely that four-year undergraduate courses mixing agriculture and engineering will be acceptable to either profession in Australia.

(3) It would not be difficult to imagine or to devise and install courses of one year (or two?) after graduating in engineering or agriculture, leading to specialised diplomas, in say agricultural engineering or mechanised agriculture, as the case may be. Would it hurt anybody's pride or status to offer such post-graduate courses also to diplomates from the technical schools and agricultural colleges? or to graduates from the Asian universities, who do not so readily conform to our bachelor standards?

Before going any further, protagonists for degree courses in agricultural engineering should read (a) a statement recently put out by the Association of Land Grant Colleges and Universities in the U.S.A. and (b) relevant extracts from the Loveday Committee Report on Higher Agricultural Education in England and Wales. Both these extracts are given here as Appendices I and II.

A Summing Up

Summing up these opportunities or possibilities, what could we look forward to in say 10, 20, or 50 years' time? (We are already 50 years late by American standards, 30 to 100 years late by Swedish standards, while World War II brought England up to date.) A feasible estimate of development perhaps, is set out in the following table.

AGRICULTURAL ENGINEERING OPPORTUNITIES IN AUSTRALIA

Engineers in Agriculture in 1963, 1973, *or* 2003?

Type of Work / Institution	Research	Extension	Teaching
Research Centre	20		
Universities	5 to 10		5 to 10
State Departments of Agriculture		30? 60?	
Agricultural Colleges	7 to 15		7 to 15
Technical Schools			?
High Schools			?
Totals	30	30	10 to 15

The total could be rounded off to read from 50 to 75 in all branches of the work x years from now.

Nonsense do you say? Fantastical? By our current standards of thinking, yes, of course. But this humble total doesn't add up to Sweden's effort, or even to the Agricultural Engineering Departments at Ames, Iowa or Davis, California.

The cost of it? Again, we can only make a guess; shall we say £100,000 a year for all services at that date x, plus some capital to start with at date say x minus 10?

This total represents about—

3 per cent. of CSIRO's current annual expenditure,

or 2 per cent. of current annual expenditure of the Australian Universities,

or 1.5 per cent. of current annual expenditure by the State Departments of Agriculture,

or 1.5 per cent. of the current annual business in farm machinery and tractors,

or 0.02 per cent. of current Australian production of the *agricultural* industries (excluding wool),

or 0.01 per cent. of current Australian production of *all primary industries.*

If the effort raised the production and/or lowered the costs by as little as 0.1 per cent. in some or all of the primary industries of Australia, would the cost of such an effort be out of proportion to the likely gain?

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APPENDIX I

Extract from the Proceedings of the 62nd Annual Convention of the Association of Land-Grant Colleges and Universities (Washington Nov. 1948) (pp. 186-188).

Statement of Policy with Reference to the Development of Agricultural Engineering in the Land-Grant Colleges and Universities.

The first curriculum leading to the B.S. degree in agricultural engineering was established in 1904. At present, plans of study in agricultural engineering are being offered in about 30 Land-Grant Colleges. Although the actual record of agricultural engineering is one of accomplishment, progress has not been as rapid as circumstances justify. The result is that to date the curricula in only three institutions and an option in a fourth have been accredited by the Engineering Council for Professional Development, which accredits curricula for the engineering profession. The colleges of agriculture and the colleges of engineering in our Land-Grant institutions are in a position to render outstanding service to the agricultural industry of this country through complete co-operation in the development of suitable curricula for training young men in agricultural engineering and related fields. Unless we in the Land-Grant colleges and universities assign ourselves to this task, we have not met the challenge of service which our institutions must render to society.

Agricultural engineering is unique in the degree to which it combines the need for work of a technical character, as in research and development in the state experiment stations and in industries serving agriculture, and work of a less technical character such as agricultural extension, farm advisory work, and farm management This circumstance should be recognised in the organisation of curricula in the agricultural engineering department. Two distinct and complete curricula are recognised:

1. *A curriculum leading to a B.S. Degree in Agricultural Engineering.*

The *objectives* of this curriculum are to prepare the student for engineering service in rural communities; for teaching, research, and extension work with colleges, experiment stations, and governmental agencies in the fields which require engineering applications; for positions in the manufacture and sale of farm machinery and farm power equipment; for advisory and managerial posts in connection with agricultural development; for positions with farm buildings and materials concerns; and for work relating to the increasing use of electricity in agriculture.

The courses comprising this curriculum should emphasize the fundamentals of engineering and agriculture to provide the student with adequate technology to serve this industry. Briefly, this requires mathematics through calculus, physics given to students in all engineering curricula, chemistry, mechanics, thermodynamics and fluid mechanics, and other basic subjects common to engineering curricula; biology, soils, field crops, animal husbandry, and other basic courses in agriculture; general studies, including humanistic and social sciences, with special attention to written and oral English and economics; and agricultural engineering subjects devoted to the engineering applications to agriculture which utilize the foundation courses in engineering and agriculture in advanced subjects taken in the senior year.

2. *A curriculum leading to a Bachelor of Science Degree in Agriculture with a major in "Mechanical Agriculture" (Farm Equipment, Farm Buildings, Farm Water Management, or Rural Electrification).*

This plan of study is for agricultural students who are interested in the production and primary processing of crops and livestock; in county agent and other extension work; in soil conservation work; and in sales and other work that deals directly with farm people. To an increasing extent, the operations on the farm are being mechanized through the use of power and machinery. Consequently, the student enrolled in agricultural curricula must have an acquaintance with machinery, power, electrical equipment, soil conservation, farm building and other agricultural engineering subjects that relate to production and processing. The courses covering these subjects should, therefore, be presented from the viewpoint of the user and consumer of farm equipment and not from that of engineering design.

In addition to the above plans of study, there should be opportunity for students enrolled in engineering, for example, mechanical engineers, to elect courses in agriculture and agricultural engineering subjects, in order to acquaint themselves with the problems of the agricultural industry. Such election of courses ordinarily would not constitute a plan of study.

In addition to undergraduate instruction, the Land-Grant college student must be afforded an opportunity for graduate programs in each of the above plans of study, leading to advanced degrees either in engineering or in agriculture.

At the present time, it is not feasible nor desirable to offer two complete curricula at every Land-Grant college. There is urgent need, however, to increase the number of institutions at which a professional agricultural engineering curriculum is available and that all professional agricultural engineering curricula be accredited by the Engineering Council for Professional Development. At least twenty institutions should offer an accredited curriculum.

The question of administrative responsibility must be considered. A curriculum leading to a B.S. Degree in Agriculture with a major in "mechanized agriculture" should be administered by the agricultural dean. Since close cooperation must be maintained by the department of agricultural engineering and the several agricultural and engineering departments, a curriculum leading to a Degree of B.S. in Agricultural Engineering preferably should be jointly administered by the engineering and agricultural deans. The teaching staff may be on either the agricultural or engineering budgets.

APPENDIX II

Extract from Report of the Committee on "Higher Agricultural Education in England and Wales." (The Loveday Committee.) Jan. 1946 (Cmd. 6728) (Pars. 133-139).

Agricultural Engineering.

133. The subject that is customarily, but in our view misleadingly, called agricultural engineering has also been reserved for separate discussion because it must be considered as a whole and because it has not received adequate recognition. Its importance derives from the fact that the most striking, and one of the most significant of the changes that have come over British agriculture in recent years, and especially during the war, is the increased use of machinery. The wartime acceleration of the process has been largely forced on the industry by shortage of labour, but the lesson has been learnt and the result will be lasting.

134. Largely, no doubt, because in wartime conditions educational development can hardly keep pace with practical progress, this fact has not (as the Luxmoore Committee noted) been reflected in the teaching of agriculture. All existing courses in agriculture and horticulture include some instruction in what is generally called "implements and machinery", but we do not believe that it is adequate. In particular, it is not sufficiently integrated with the teaching of husbandry. A growing range of implements and machinery has perforce been dealt with, but the implications of this growth have not been fully grasped. With the gradual mechanisation of nearly every branch and process of farming from milk production to fruit growing and from ploughing to harvesting, the study of farm machinery can no longer be treated in isolation but must be transformed into a study of the mechanical aspect of husbandry. So far as higher education is concerned, we have emphasized that technical skill and manual dexterity are outside its province. It is merely an application of this rule to point out that the art of plough-setting and the grease-points of a tractor are not suitable subjects for study at university level. This is not to say that the student must never see or handle a plough or a tractor (cf. paragraph 27). But the use and care of individual machines should be taught only for purposes of illustration and subordinated to the teaching of "mechanized husbandry."

135. Such teaching demands suitably qualified teachers. Concurrently the farmer needs advice on the choice and use of machinery. Both teachers and advisers must be fed with new knowledge, which can be be furnished only by research. The Ministry has established the National Institute of Agricultural Engineering to serve as a research station, but no regular means exist of supplying the Institute with trained staff. Indeed no provision has yet been made in this country for the systematic training of research workers, advisers or teachers in agricultural engineering or mechanized husbandry. Again this deficiency is in sharp

contrast with the abundant facilities provided in other countries, notably in Canada and the United States of America. Unless it is remedied—not necessarily by imitating North American methods — British farming will be at a disadvantage and incidentally British industry and trade will suffer. The farmer wants machinery as well as advice on what machinery he ought to have and how he ought to use it. The British manufacturer can supply a reasonable proportion of his needs and at the same time produce a valuable article of export.

136. The prime necessity from the point of view of both user and maker is research. The agricultural engineering industry in this country will clearly have to undergo great changes if it is to gain and keep a reasonable share of the market either at home or overseas. Its organisation and methods of production are none of our business, but the kind of product it turns out is relevant to our enquiry. It seems to us evident that the British manufacturer's best prospects of competing successfully in both home and overseas markets lie in producing fresh types of machinery developed in accordance with new ideas about application of mechanical power to the processes of agriculture.

137. We appreciate that in the past new implements and machines have been invented or suggested mainly by enterprising farmers with a mechanical turn of mind, but this is at best a slow and chancy method. Future development must spring from more systematic and more radical investigation. Some recent criticisms of the traditional use of certain implements may be exaggerated but they point a useful moral. The question "How can such and such an implement be improved?" or "What machine can be devised to reduce the effort demanded by such and such a process?" does not go deep enough. Taking as an example cultivation machinery, which plays a bigger part in farm work than any other kind of machinery and which presents specially difficult problems because it affects the living plant, the first question to be asked is "What effects should cultivation produce and how can those effects best be produced?" This is not a purely mechanical problem for the engineer. In order to define the questions that he must answer, the physical properties of the soil and their influence on the growth of the plant must first be investigated. Such fundamental research requires the cooperation of the soil physicist, the plant ecologist and the engineer. It can best be carried out at a university that contains departments of agriculture and engineering, as well as pure science, with suitable facilities for research.

138. The next stage of research is the designing and testing of machines that will produce the desired effect and can be manufactured for sale to the farmers at a price proportionate to the value of what they will do for him. This stage seems to us to be the function of a research station, like the National Institute of Agricultural Engineering, working in conjunction with the research departments of the manufacturing firms, but it will demand the collaboration of the National Agricultural Advisory Service in providing facilities for extended field trials. The work requires the services of men with an expert knowledge of mechanical engineering, but it must also draw on agricultural knowledge, not least in relation to the economic aspect, which is the crux of farm mechanisation.

139. We do not believe that both needs can be satisfied by a single type of expert labelled "agricultural engineer". So far as we have been able to discover, the training hitherto provided in the United States and Canada has in the main taken the form of degree courses specially designed to turn out such a composite product, but we understand that current opinion in America is tending to look for a better method. For our part we have come to the conclusion, in respect of every kind of professional career that we have had to consider, that any attempt to turn out a highly trained specialist by means of a single course of training at undergraduate level is bound to be unsatisfactory save for the exceptional student. We believe that this is true of "agricultural engineering" and that a degree course in such a subject is likely to produce neither good engineers nor good agriculturalists.

Furthermore we believe that, ignoring misuses of language that extend to other branches of engineering and do not directly concern us, the term "agricultural engineer" is used ambiguously to cover two distinct functions which require different qualifications. On the one hand men are wanted who will apply a thorough training in mechanical engineering to the needs of agriculture; on the other hand men are wanted to bring a profound knowledge of husbandry to the problems of farm mechanisation. The first class, who may properly be called agricultural engineers, are primarily engineers with a knowledge of agriculture. The second, who should be described as experts in farm mechanisation or mechanised husbandry, are primarily agriculturists with a knowledge of engineering. The two classes stand to each other in a relationship parallel to that of the agricultural scientist and the husbandry expert.

THE PRODUCTIVITY OF SUBSOIL

By G. W. LEEPER

Subsoil generally receives less attention than it deserves. It is true that soil surveyors and pedologists give it great attention; but in general the scientist, like the farmer, is interested in the surface material which he can see and treat. This is natural, but at times even good scientists have either ignored subsoil or have written of it with disapproval, as though it were rather horrible. This is a popular way of thought, which, like some other popular beliefs, has not yet disappeared from scientific teaching.

"Subsoil" is used here for anything more than a foot below the surface, beyond the reach of ordinary implements. It could include either B or C horizon, but the term will be mostly confined here to the B horizon, especially in leached soils, and in particular in the Australian podzols, where the B horizon has a concentration of colloid.

We may consider first its chemistry. In the wetter climates the nutrient elements are washed out of the surface. We sometimes read that they concentrate in the B horizon, but this seldom happens and commonly they are washed away completely. Only in the moderately wet climates, secondary $CaCO_3$ may form in the third foot of the profile. In general, the total supply of most elements is highest at the surface, where they are continually brought by plants which carry them up through the roots to the leaves. This total supply may fall decidedly or only slightly with depth; some elements may pass through a minimum in the sub-surface (Fig. 1a).

Even in terms of totals the subsoil is poor; but when we consider the amount of nutrient available to plants it is far poorer; this figure falls very sharply with depth, as the source changes from high-grade at the surface to low-grade in the subsoil. (Fig. 1b). There may be several reasons for this fall. The sim-

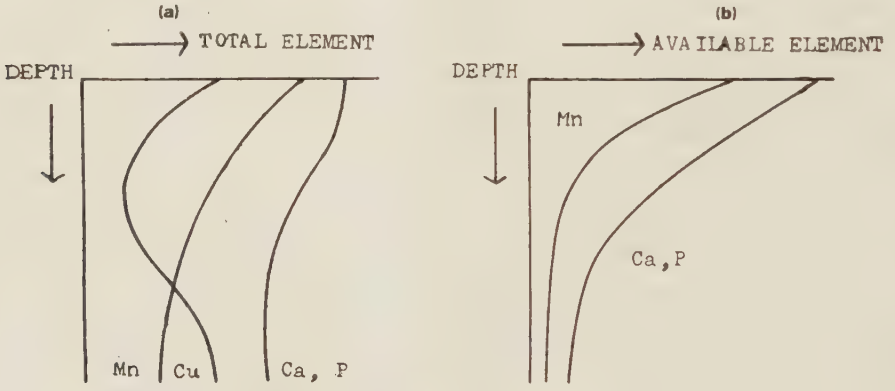

Figure 1

G. W. LEEPER, M.Sc., is Associate Professor in Agricultural Chemistry, University of Melbourne. This paper is based on the Presidential Address to the Melbourne University Agricultural Society, 1951.

plest reason is just dilution with colloid. This applies especially to phosphorus. An excellent example was found by Skene and Freedman (1944) in their survey of the "red-brown-earths" of Shepparton, where they noted that the ratio of phosphorus to clay colloid was one-ninth as high in the B as in the A horizon (0.026 and 0.23 per cent. respectively). A second effect is shown by calcium, which in most Australian soils makes up a continually smaller proportion of the exchangeable ions with depth. The work of Marshall's school (Marshall, 1950) shows that calcium making up only 30 per cent. of the exchangeable ions is of little use to plants—far less than half as good as 60 per cent. calcium. Manganese provides a third effect. It seems likely that the manganic oxides present in B horizons are more highly crystalline than the fresher oxides in the surface, and provide less manganese to plants on that account.

These general relations hold for many Australian soils. But some of the exceptions are also interesting. Two of these come from the poorest country of all. Firstly, on the deep sands near Perth, where pines have been established only after giving superphosphate to each tree, it appears that the main reserve of phosphorus in the soil is in the organic layer (a B horizon) from 6 to 8 feet below the surface (Southern, 1940). Even if the trees took up all the meagre phosphorus in the upper layers (14 pounds per acre in the top two feet) they would still need this lower layer, with five times as much phosphorus, to grow to commercial size, which in fact they do. In this case the initial dressing of phosphate has enabled the roots to reach these deep supplies. Secondly, on Coonalpyn Downs, a soil notoriously deficient in the sandy surface contains a remarkable reserve of potassium in the clay of the B horizon (Taylor, 1935). Here again, the initial application of calcium-sulphur-phosphorus-copper-zinc plus the nitrogen of the legumes enables grasses to use this reserve and so eventually to enrich the surface.

This last point can be related to the suggestion that trees have a special place in the wettest climates, namely to trap the nutrients on their way through the subsoil before they are lost in the rivers. This links up also with the fact that the C horizon even of poor soils may have fair reserves of primary minerals. The B horizon is too shallow to have primary minerals and too deep to have biological concentrations.

The chemical poverty of B horizons may also be partly responsible for some of their physical faults. If few roots penetrate a layer for either chemical or physical reasons, the structure becomes worse and fewer roots still will penetrate. By placing a fertilizer in the subsoil we may provide some essential element (calcium, say) which allows the roots to penetrate and create new channels for air and water. This experiment has been reported from Missouri (Woodruff and Smith, 1947), where the subsoil was given lime and phosphate and was then penetrated by the crop's roots.

So much for the B horizon in its proper situation, out of sight. When erosion has laid bare a former subsoil, we have a new problem. Some of the spokesmen for soil conservation have given the impression that this case is hopeless, and that is a widespread popular impression too; as though there were something about subsoil in itself that made it positively bad. At the worst, if it is left to inhuman nature, this is raw material for weathering, and eventually an ordinary soil will form as it has on other materials. The only sensible question is, how long will it take?

We need not regard seriously the often repeated statement that it takes a thousand years to make an inch of soil. Rather we are interested in how short a time it will take under the hand of man. No doubt gardeners on countless occa-

sions have solved this problem, yet it is hardly mentioned in scientific literature. Looked at analytically, the former B horizon may contain 50 per cent. of clay and will be low in many of the necessary elements. There is no reason why it should not be made as good as a good agricultural soil containing the same amount of clay. Chemically, we simply add the deficient elements (calcium, phosphorus, nitrogen, and the rest); this idea is already commonplace in dealing with poor A horizon in the southern parts of Australia. Physically, we have to create structure; the soil disperses in the rain and sets hard on drying and only for short periods will it allow plants to germinate. On the yellow clay horizon of the Australian podzol and the red clay of the red-brown earth, this is the whole problem. (The red clay of the krasnozem often has good enough structure already though coarser than that of the A horizon.) Structure can be built up by increasing the organic content, and this can be done by growing any plant. If the roots and surface litter add annually one ton of organic matter to the top six inches over an acre, then in ten years there will be about 1 per cent. of organic matter in the soil, and so on. In general, the first colonists are commonly weeds, which can begin growth under harsh conditions. If they are helped with all the needed elements, they grow well and provide enough shelter for more economic species. For example, in pots filled with the yellow clay of the B horizon on Melbourne's silurian shales (as unpromising a subsoil as can be imagined) hogweed (*Polygonum aviculare*) and hairgrass (*Aira sp.*) are good pioneers, and ribgrass (*Plantago lanceolata*) and *Phalaris tuberosa* have then made excellent growth in the second year of the experiment. The same process is described for trees growing on industrial waste land. (Whyte and Sisam, 1951). It is difficult to estimate how long a time is needed before such land can be safely grazed or ploughed.

A more rapid improvement of raw subsoil kept in barrels is reported by Hopp and Slater (1948) who added fertilizer, straw and manure, together with earthworms which both buried organic matter and left channels for air and water. The soil with their best treatment grew a good crop in the second season of the experiment. However, their subsoil, in which earthworms could thrive in wet weather, must have been better than that of Melbourne.

Since the address here summarized was given, a long article on subsoils has appeared (Winters and Simonson, 1951) with examples largely drawn from the United States of America.

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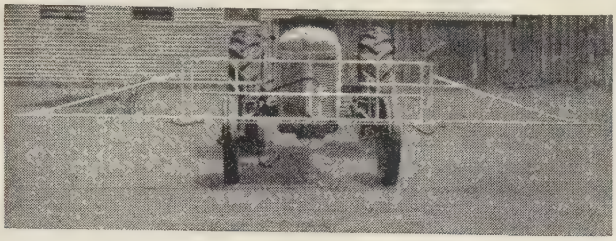

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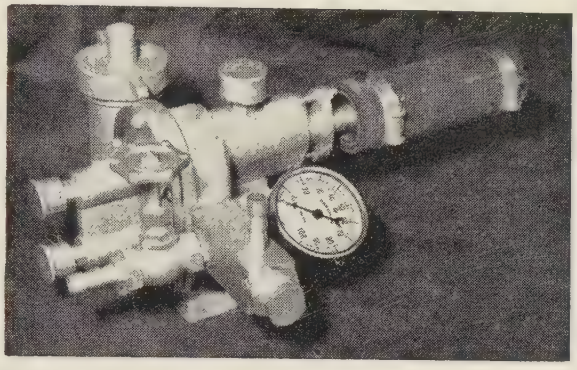

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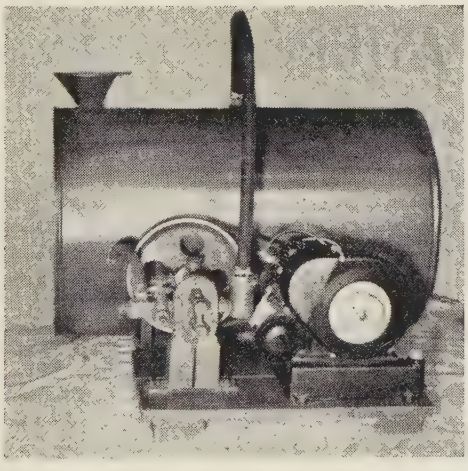

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SOME ASPECTS OF SOIL FERTILITY IN THE CEREAL AREAS OF VICTORIA

By H. J. SIMS

In Victoria, a large proportion of the agricultural research in the past has been concerned with cereals. Despite this attention, there are still many matters requiring more investigation in a research programme. Probably the chief of these is soil fertility in its various aspects. It is the aim of this review to discuss what has been done in this field and to point to some of the gaps in our knowledge. Some of the problems require further basic research, while others require applied or regional research.

Soil fertility is a complex matter, but it can be briefly defined as the ability of the soil to produce, and continue to produce, high yielding crops with satisfactory quality characteristics. It is affected by chemical, physical, organic and microbiological factors in the soil.

The relationship between soil fertility and soil erosion is not discussed in this review.

FERTILITY CHANGES IN AUSTRALIAN WHEAT SOILS

Two methods of examining soil fertility changes have been used in Australia—that of examining district yield trends, and that of examining yield trends on experimental areas farmed according to definite rotation systems.

The most complete analysis of the changes in wheat yields in Australia is that of Cornish (1949) in South Australia. He considered the yield trends in each Hundred of that State and divided them into four types—(a) increasing yields, (b) decreasing yields, (c) increasing followed by decreasing yields, and (d) yields generally stationary. In the older settled areas, yields usually showed downward trends. In those Hundreds where yields were increasing, the rate of increase was steadily diminishing and would probably become negative in the future.

In Victoria, no such complete study has been undertaken. The average yield per acre has shown a gradual increase during the past fifty years, but much of this increase is attributable to improved varieties and farming practices. Hackwell (1938) commented on the marked increase in the average yield per acre in the County of Lowan. He attributed this to technological advances.

Miller (cit. in part by Skerman, 1951) pointed out that, in certain typical wheat-growing parishes in each of the main cereal-growing districts, there was little or no evidence of a yield decline over the past forty years: in fact, there was some evidence of yield increases, and the average Victorian wheat yield for the five post-war years was far higher than for any other five-year period. He did not analyse the relative importance of the factors concerned in these yield changes, but stated that fertility trends had been masked by highly favourable seasonal conditions or the use of improved varieties. He concluded that some soils had improved in fertility during the period under review. Statistical data showed that in the "usual" farming system the land, after growing wheat, reverted to pasture grazed by stock for periods ranging from one to six years, with an estimated mean of two years.

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Some data concerning rotation practices on wheat farms in Victoria and New South Wales have been published by Crawford (1952) and Parish (1952). Crawford tabulated the "apparent length" of the rotation adopted by wheat farmers indicating that, on the Victorian survey farms, approximately one-third of the total arable area was sown to wheat. No information was given concerning the area of pasture on these farms.

Baldwin (1949), in a survey of the Whittlesea district, where oaten hay has been grown for a long period, stated that it was hard to find good evidence of soil exhaustion by cropping, although the general impression was that soil fertility had declined. Parish records over the past seventy years do show a slight decrease in average yields of cereals, in spite of technological advances; but it was impossible to find particular instances of exhausted land.

The Rural Reconstruction Commission (1944) considered there was no doubt that in thousands of farms in Australia soils had deteriorated to a marked degree. The deterioration had been gradual, and, when unaccompanied by obvious signs of physical erosion, was frequently quite unsuspected.

Information concerning yield trends of crops grown in definite rotation systems has been obtained by the analysis of yield data from long-term rotation trials. Such analysis in Victoria by Forster (1939) and Sims and Jardine (1951), and in South Australia by Wark (1942) and Woodroffe (1951), has shown that, despite the use of higher yielding varieties, there has been no increase in the yield of rotations that do not include a pasture period or a legume, but that the rotations including a pasture period have shown beneficial effects.

In Western Australia, Millington (cit. Underwood, 1952) has shown that the yield of wheat per inch of March-October rainfall has declined since 1925.

Penman (1951) has shown that rotations without legumes or a grazing period have led to a deterioration in soil organic matter and total nitrogen. Teakle (1951) and Forster (1950) have quoted substantial losses in soil nitrogen under farming systems without a pasture period or lucerne.

With respect to soil structure, Clarke and Marshall (1947) have shown that continued cultivation in a fallow-wheat rotation seriously reduced percentage aggregation in the soil. Woodroffe (1951) has shown deterioration of soil structure under regular cropping without pasture, but that a legume crop (peas) or a pasture period appreciably lessened the rate of decline.

On the other hand, evidence is accumulating concerning the value of legumes in improving soil fertility and increasing crop yields. Subterranean clover is particularly important in the higher rainfall wheat lands (Morrow and Hayman, 1940; Hayman, 1943; Morrow, Killeen and Bath, 1948; Shier and Cullinane, 1948; Bath, 1951 a. and b.; Anon., 1951d) and has revolutionised cereal growing methods in areas where it can be grown. Red clover has proved valuable in maize and oat rotations (Anon., 1948) and in many districts naturally occurring legumes are important. Purchase, Vincent and Ward (1949) have presented data assessing the possible contribution of such legumes to the nitrogen economy of some New South Wales wheat soils.

The need for inclusion of a grazing period and legumes in cereal-growing rotations is apparent, but much detailed regional research is still required regarding the application of these general principles.

CHEMICAL FERTILITY

When considering methods of improving soil fertility, the problem of a low chemical fertility status of soils is probably the simplest to deal with, because, in most instances, chemical deficiencies can

be remedied simply by the addition of fertilizers. In Victorian cereal districts, the chief deficiencies remedied by such means have been those of phosphorus, zinc and nitrogen.

Phosphorus

Superphosphate has been the principal fertilizer used by wheat growers for more than fifty years, and its use is regarded as standard practice in Victoria. It might therefore be assumed that no further work with respect to phosphate application in Victoria is required. But we have very little data concerning the value of forms of phosphate with lower water solubility, or of the effect of fineness of grinding on the availability of such materials to the plant. This was realised, particularly, when information on such matters was required for formulating policies to meet the recent threatened shortage of sulphur for superphosphate manufacture.

A second aspect concerns the residual value of superphosphate applied to previous crops. At Rothamsted, a residual effect of phosphate applied nearly 50 years previously has been recorded (Anon., 1950-51). In Western Australia (Teakle and Cariss, 1943) and South Australia (Anon., 1950; Williams, 1950), it has been shown that, on land that has received fairly heavy dressings of superphosphate regularly for a number of years, the response to superphosphate is now lower than in former years, and that there is little response to current applications when the land has received, in previous dressings, a little more than 15 cwt. of superphosphate per acre. When this stage is reached, it is considered that only maintenance requirements need be applied—30 lb. of superphosphate for a 20-bushel crop.

In Victoria, there are indications of similar trends. For instance, at Longerenong College during the years 1912-16, when previous superphosphate applications had been small, the use of 1 cwt. of superphosphate gave an increase of 24 per cent. in wheat yield compared with no fertilizer; but the response obtained to the same fertilizer application during the years 1947-50 was only 6 per cent. Approximately 15-18 cwt. of superphosphate had been applied to the land during the intervening 35 years.

At the Mallee Research Station, Walpeup, the use of 90 lb. of superphosphate per acre on wheat gave an increase over no fertilizer of 27 per cent. on comparatively new land during the five years 1933, 1935-38 (previous application of superphosphate less than 1 cwt. per acre); the response to the same dressing during the four years 1948-51 was 11 per cent.; in the interval the land had received approximately 5 cwt. of superphosphate per acre.

The results of the wheat manurial trials at Charlton also offer support to the foregoing. The farmer on whose property the plots are situated has been a heavy user of superphosphate for many years, and only very small responses to superphosphate are obtained in the plots on his land (Anon., 1951a p.16).

In considering the superphosphate trials in Victoria as a whole, however, it has been found that in recent years most of the trials, which are conducted on a wide range of soil types, still show that the increases in wheat yields warrant the superphosphate dressings given, and that, in many instances, the dressing could be profitably increased by 20 per cent. or more. It is thus clear that more information is required concerning the effect on current crops of superphosphate applied in the past.

In discussing phosphate reversion and residual effects, Leeper (1948) commented that we have deplorably little information as yet on the effect of residual phosphate added to Australian soils during this century. He stated that when phosphorus is "fixed" in the soil, it may be combined as a calcium compound or adsorbed by iron or aluminium compounds. The formation of calcium com-

pounds is the most desirable type of "fixing". If the soil is weakly alkaline (pH about 7.5), the calcium phosphate then formed is soluble enough to supply the plant's needs. But if the soil is rich in lime, particularly at a pH of 8 or more, as in the case of many Mallee and Wimmera soils, the phosphate is fixed in the form of a basic compound hydroxyapatite, which has an extremely low solubility. It may therefore be expected that the residual phosphate in Mallee and Wimmera soils would have a smaller effect on crop yields than would a similar amount in soils at the Waite Institute.

A big difficulty in getting information on residual phosphate is the difficulty of finding suitable experimental sites with known histories. On this account, the method now being adopted in Victoria is to estimate the "available" phosphate in the soil and to correlate this with fertilizer response and also with previous fertilizer usage. There are many difficulties with respect to the estimation of available phosphate, and it seems probable that different methods will have to be used for alkaline and acid soils. It appears probable that, in the future, the recommendation for the amount of the superphosphate dressing will be based on data from soil samples.

Zinc

The use of zinc as a fertilizer has now become accepted practice in some Victorian districts. Responses to zinc have been obtained only on certain soil types—particularly on the "black" soils of the Wimmera. The chief matters on which more information is required are the period of effectiveness of an application of zinc, and the reasons for varying responses to zinc on red and Mallee soils. On these soils, responses to zinc are obtained in some of the wetter seasons, but, even within the one year, variable responses have been obtained in adjacent districts.

Nitrogen

In Australian cereal production, until recently, we seemed complacent regarding the nitrogen fertility of our soils—which, actually, is low by world standards. For example, the Wimmera is regarded as rich wheat-growing land, but the total nitrogen of virgin Wimmera "black" soils is only 0.115 to 0.15 per cent. (Penman, 1951), compared with 0.308 per cent. in Illinois prairie soils, 0.341 per cent. for seven rich Russian soils, 0.373 per cent. for Manitoba prairie soils (King, 1895, p.107), 0.14 to 0.30 per cent. for the brown soils of Saskatchewan, and higher values for the dark brown soils (Doughty, 1948; Anon., 1949).

Despite the relatively low nitrogen content of the soil, nitrogenous fertilizers have little or no effect on the yield of wheat grown on fallow, as large amounts of nitrate accumulate during the fallow period. Yield responses, however, are obtained in the higher rainfall districts on stubble sown crops in regular cropping rotations; but not when such crops are grown after a long period of leguminous ley. As this type of farming increases, less nitrogenous fertilizers will be required for cereals.

In the higher rainfall districts (over 18 in. annual rainfall), it has been considered that the value of the fallow is in the production of nitrate, rather than in the conservation of moisture. In the lower rainfall areas, however, high nitrogen without adequate moisture can lead to "burning-off" of the crop.

This has been demonstrated at the Mallee Research Station, Walpeup, where, in an experiment to demonstrate the effect of loss of surface soil on yield, plots were prepared by artificially removing various depths of top soil while others were left with the normal soil surface. All plots were then fallowed. The crops on the plots where no soil loss had occurred made best growth in the winter and spring, but, when the moisture stress came, the crop "burnt off" and in many

years did not yield as well as those plots which had lost 3 inches of surface soil and which were more conservative in their early growth. This same tendency to "burn off" on soil higher in nitrogen has been noted in crops grown after spelling with barrel medic, both at the Mallee Research Station and Longerenong College. There is apparently an optimum nitrogen status for different soil and climatic conditions, and more information is required in this regard.

In considering fertility changes, as reflected in crop yields, it has been found that the farming practices adopted may obscure a real decline in the soil fertility related to the nitrogen status of the soil, although other factors are, no doubt, involved. Miller (cit. in part by Skerman, 1951) referred to a cultivation trial at Longerenong College in which fallow yields averaged approximately 35 bushels per acre, over a period of 15 years, compared with 15 bushels per acre from non-fallow. However, when all the area was brought under fallow, the respective yields were 31 and 37 bushels per acre; that is, the plots formerly yielding highest now yielded 6 bushels less. The soil nitrogen was 0.080 per cent. in the old fallowed land, compared with 0.091 per cent. in the previously non-fallowed land.

Another similar type of result was obtained in the Nhill district. After the discontinuance of a long-term fertilizer trial, residual trials were conducted on the site. For the 20 years that fertilizer was applied, the average yield from the "no manure" plots was 29.6 bushels per acre, and, from the "super. 1 cwt." plots, 32.4 bushels per acre. At the completion of the above period, the area was cropped, without fertilizer, for one cropping cycle, the average yields being 32.8 bushels per acre from the former "no manure" plots and 33.6 bushels per acre from the former "super. 1 cwt." plots. The area was then cropped using a dressing of 1 cwt. of superphosphate per acre over the whole site, and the average yields were 32.4 bushels per acre from the former "no manure" plots and 27.4 bushels per acre from the former "super. 1 cwt." plots. The soil nitrogen in these plots was 0.095 per cent. and 0.089 per cent. respectively.

There would appear to be at least six possible avenues of nitrogen replenishment in the soil:—

(1) *Use of fertilizers.*

(2) *Addition of nitrogen in rain water.* Leeper (1948) suggests that the amount of nitrogen added to soils in temperate Australia by this means may be about 5 lb. per acre per annum. This could be sufficient for the requirements of a 15 bushel Mallee crop if the land were cropped every fourth year.

(3) *Adsorption from the atmosphere.* Ingham (1950) considers that ammonia and other nutrients can be adsorbed from the atmosphere by cellulose and other materials. If this is so, straw and trash could be expected to adsorb nitrogen, but no data to indicate that this occurs to any appreciable extent have been published.

(4) *Nitrogen fixing by free-living nitrogen-fixing organisms.* Three groups, Azotobacter, Clostridium and some blue-green algae are generally recognized to have this power (Russell, 1950). It appears that these organisms have no significant role in the nitrogen economy of our cereal districts (Swaby, 1939; Jensen, 1940).

(5) *Photochemical fixation of nitrogen* by sunlight is claimed by Dhar in India (cit. Russell, 1950, p.304), who stated that this fixation occurs more rapidly when readily decomposable carbohydrate is present in the soil.

(6) *Fixation of nitrogen symbiotically by leguminous plants.* This is certainly the most important means, or possible means, of adding nitrogen to Australian cereal soils. The value of legumes in improving soil fertility has been realized for thousands of years, but the symbiotic relationship was only defined about 70

years ago. Symbiotic nitrogen fixation is not confined to leguminous plants; Russell (1950, p.303) lists other tropical and sub-tropical plants which probably fix nitrogen symbiotically.

LEY FARMING

The improvement of soil fertility by subterranean clover leys in districts where subterranean clover will flourish is now well known, and many results have been accumulated regarding cropping methods to be adopted in such a farming system. This system of cereal growing has now been generally adopted in the North-Eastern and Western Districts of Victoria, with advantage to both the yield and the quality of the produce and an increase in stock-carrying capacity of the farm compared with the older system of cropping.

At the Rutherglen Research Station, it has been found that the increase in soil nitrogen is slow in the initial years after legume establishment, presumably because of low plant population. It seems that the average pasture needs two years for the establishment of the legume in sufficient quantity to fix the nitrogen required for a subsequent wheat crop. After this, nitrogen has accumulated at rates varying upwards from 30 lb. per acre per annum, depending on the season (Penman, 1951). A well established sward, in a run of good seasons, can add nitrogen to the soil at the rate of 200 lb. (equivalent to about 10 cwt. ammonium sulphate) per acre per annum. Subterranean clover leys established for over 20 years are still showing steady annual increases in soil nitrogen.

Richardson (1938) has shown that the typical nitrogen content of Rothamsted arable soils is about 0.11 per cent., and of old grassland about 0.25 per cent., and estimated that it took about 25 years for half this gain to take place.

There is scope for a substantial increase in Victoria in the area of land farmed under a clover-ley system in districts where subterranean clover can be expected to grow, and also for an increase in cereal acreages in the districts where subterranean clover now flourishes. One problem that arises is the need for improved cereal varieties for growing under such conditions. There is also need for regional research with respect to the extension of the legume-ley system of farming into the lower rainfall cereal areas. Some of the problems appear to be:—

1. The production of strains of subterranean clover that will grow in the lower rainfall wheat areas, as subterranean clover appears to have advantages in regeneration capacity over the medics. Such strains may be obtained by introduction from overseas, by selection, or by hybridization, as is being attempted by Millington in Western Australia.

2. The defining and mapping of areas suitable for the growing of the various strains of subterranean clover. This clover shows a preference for acid and neutral soils (Trumble and Donald, 1938). It has been noted that, at Rutherglen, where subterranean clover flourishes, the regular application of lime, in addition to superphosphate, has depressed the growth of clovers (Anon., 1951b p.10). On the other hand, Tiver and Crocker (1951) have suggested that ecotypes of subterranean clover tolerant to alkaline conditions may have evolved in South Australia. It may be that soil pH governs the availability of plant foods, and investigations should be undertaken to see if the range of subterranean clover in the more alkaline soils can be increased by the use of minor elements, particularly zinc and copper. At Longerenong College, the growth of subterranean clover is greatly stimulated by zinc (Hackwell and McKeon, 1941).

That factors other than soil pH may be involved is suggested by the fact that subterranean clover grows well under irrigation at Longerenong Col-

lege (pH 8.5). This may be associated with active plant growth in early autumn, when absorption of zinc by the plant is more efficient because of favourable conditions of light and temperature (Trumble, 1949).

3. The ascertaining of the most suitable medics for the Mallee and the Wimmera. Barrel medic is the most useful species at present available. At the Mallee Research Station *Medicago littoralis,* which is similar in many respects to barrel medic but which has a smaller burr, appears to have advantages, particularly in its capacity to regenerate. The range of material available for investigation can be increased by introduction, selection or hybridization. All methods are being used by the Department of Agriculture.

4. The investigation of the possibility of other legume types for the cereal areas. Such investigation would include crop legumes—peas, vetches, gram, etc., and an extension of the Western Australian programme of investigating native legumes.

5. The determination of the optimum length of the ley, and then of the cropping period. Experiments have been commenced at the Mallee Research Station and Longerenong College to supplement the work being done with subterranean clover at the other stations.

6. The determination of the carrying capacity of the legume-ley pasture. The results (Hayman, 1943; Morrow, Killeen and Bath, 1948; Anon., 1951c) indicate that subterranean clover greatly increases carrying capacity; increased carrying capacity by medics was shown by Flemons (1952).

7. The investigation of the interaction of the plant and the animal on soil fertility. In addition to the effect of leguminous crops during the grazing period, it has been found that the grazing of cereal crops and grasses has given yield increases. This may be due to soil structure improvement or to nitrogen being brought into more available form through the animal manure.

8. The type of soil preparation after the ley period. At Rutherglen, it has been possible to eliminate fallow, except for weed control purposes. At Dookie, it appears that a later or "spring" fallow may be the most satisfactory. It is considered unlikely that fallowing can be eliminated in the main cereal-growing districts.

9. In districts where fallowing can be eliminated, and several successive crops are grown after the ley period, it is necessary to determine the best way of handling the stubble from the previous year's crop.

SOIL STRUCTURE, ORGANIC MATTER AND MICRO-ORGANISMS

Soil structure—the aggregation or otherwise of the individual soil particles into water-stable crumbs—is an important aspect of soil fertility. More research is required on soil structure, both in regard to the factors involved in the improvement of structure and to the development of suitable measures of structure. On this point, Quirk (1950) suggests that shaking for shorter periods than previously recommended has advantages when the effects of differential cultural treatments on structure are being studied.

It is well known that regular cultivation leads to deterioration in soil structure. Howell (1911) commented that the deterioration of structure of certain Wimmera soils—particularly red types—was apparent in 1901, after 30 years of cropping. Downes (1949) has shown that, in the Dookie district, structure deterioration has been greater on some soil types than others. Clarke and Marshall (1947) report that the major part of the deterioration that they found in the soils they examined occurred in the first five years of cultivation.

It has been shown at Rutherglen (Penman, 1951; Downes and Leeper, 1939) that the percentage of water-stable aggregates is much greater in clover ley ground than regularly cropped ground. Recent work also at Rutherglen has shown that apparent density or volume weight increases linearly with the length of cultivation after the ley spell. In 1951, which was particularly wet at Rutherglen, it was clear that land growing its first crop after a ley period was superior in its ability to "take" water, and gave a better crop germination, and, associated with this, a better control of weeds and subsequent wheat yields than did the areas which had been cultivated for some years. These improvements in structure have been obtained with annual legumes and grasses, but little local work has been done with perennials in this regard. Many workers in America and Russia have stressed the importance of perennials, particularly perennial grasses, in improving soil structure. It might be thought that perennials would have no place in our cereal districts, but many of our native grasses are perennials, and lucerne does well in some cereal areas, particularly in parts of South Australia.

Goudie (1952) discusses improvement in soil structure in relation to permeability of the soil to irrigation water in a soil typical of many Northern district cereal areas. It took two years before any of the leys gave an improvement in structure. Unfortunately, the results with subterranean clover were spoilt because of invasion of other species, but white clover gave quicker improvement than lucerne. The Soil Conservation Authority of Victoria (1951) reports that, on one soil type, the soil under improved pasture had an infiltration capacity of at least double that of unimproved pasture nearby.

Breakwell (cit. Skerman, 1951) has suggested that, in many instances, fertility decline may be due to a structure breakdown rather than to a nitrogen decline, and submitted that more attention should be given to means of maintaining organic matter by such means as stubble mulching and the frequent use of short-term pasture of non-legumes—which are easier to grow than legumes. Canadian results (Doughty, 1948; Anon., 1949) indicate that the return of stubbles to the soil may be sufficient to maintain the organic matter content—but the soils studied have a high nitrogen content.

Penman (1951) reviewing Victorian and overseas data, considered "it is not so much the removal of nutrients by crops as the keeping bare of the land, and perhaps the working of the land, that promote decline of soil organic matter and structure". Theron (1951), in discussing the nitrification of organic matter under fallow and under grass, has shown that nitrification is repressed by the presence of living roots in the soil.

The effects of the physical characters of the soil on efficient root establishment and functioning are very important in plant growth as these affect the area from which the plant derives its nutrients. It has been found, also, that nitrification is slower in poor-structured soils, and that poor soil aeration may result in the loss of added nitrogen because of dentrification (Baver, 1951).

A new approach to soil structure improvement is by the use of synthetic soil conditioners. The Monsanto Chemical Company has produced materials they have called krilium, and other soil conditioners are now being marketed. At the present anticipated prices these materials will not be of use in cereal districts, but it is possible that further research may extend their field of economical use.

Outstanding work on the relationship between micro-organisms and soil aggregation, and the influence of humus on soil aggregation, has been done by Swaby (1949, 1950). He has stressed the value of fungal hyphae, actinomycetes, gum-forming bacteria and humic acid in improving aggregation.

RELATIONSHIP BETWEEN SOIL FERTILITY AND CROP QUALITY

Quality in a product is difficult to define, in that the criteria of quality varies according to the intended use of the product. Different characteristics are required in wheat for bread-making and for biscuit-making. Normally, references to baking quality in wheat refer to its suitability for white bread-making, as that is the principal utilization of Australian wheat. The suitability of wheat for this purpose is influenced by the quality and the quantity of its gluten. Gluten quality is a varietal characteristic, and much effort has been directed by the plant breeder in producing wheats of higher baking quality.

Although it is contended in some quarters that quality has been neglected in favour of yield by many plant breeders, this is not the case, and the wheat varieties now grown in all States are generally superior in flour quality to the varieties grown 25 years ago. It is considered that further advances will be made in varieties of the future in combining improved flour quality with high yielding capacity and that maximum yielding ability has not yet been attained.

On the other hand, gluten quantity is influenced principally by climatic and soil factors, although there is a small varietal effect. Within any one variety of wheat, baking strength is directly related to protein quantity. In Victoria, it has been found that, for soils that have been given similar preparation for sowing, the protein quantity shows a close correlation with total nitrogen in the soil. For example, at Rutherglen, an increase in soil nitrogen from 0.06 per cent. to 0.11 per cent. has given an increase in protein of the grain from 8 per cent. to 10 per cent. In the Wimmera, it has been found that, on the average, each increase of 0.01 per cent. in the soil nitrogen is associated with an increase of 1 per cent. in the amount of protein in the grain (Anon., 1951a, p.28). At the Mallee Research Station, loss of topsoil by erosion, which causes a decline in soil nitrogen, is associated with lower protein in the grain.

Shier and Cullinane (1948) have shown that in Western Australia, the "strength" of wheat has been quite definitely improved by the use of a legume in the rotation, due to the improved nitrogen status of the soil. Graham (1948) has indicated that in New South Wales quality deterioration is manifested in many cases by "mottling". This condition did not appear as a commercial problem prior to about 1930, but its incidence since that date has been serious.

It appears that a decline in soil fertility is reflected in quality characteristics of the grain before it is shown in declining yields.

Finch and Underwood (1951) have shown that the thiamin content of the grain was markedly higher in grain grown after a subterranean clover ley than in grain from regularly cropped land, and, in fact, that there was an excellent correlation between the amount of protein and thiamin in the grain; therefore, methods that increaase grain protein should increase thiamin also.

This relationship between soil nitrogen and protein and thiamin in the wheat is particularly important, and emphasises the need for the extension of research work on the nitrogen fertility of the soil and its improvement by legume leys.

CONCLUSION

There is great need for research to provide more knowledge regarding the interrelationships between the cropping phase and the pasture phase of rotation systems, and the effects of crops and pastures on soil fertility, crop yield and quality. Further information on pasture plants suitable for use in such rotations is needed, together with data on cultivation methods and fertilizer usage. The methods of fitting these rotations into

farming systems must be worked out in relation to farm size and capitalization.

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TECHNICAL PAPERS

STRUCTURE BUILDING IN HALOMORPHIC SOILS

A REVIEW OF WORK IN PROGRESS AT DENILIQUIN

By K. P. BARLEY

Summary

The colloids of many Riverine soils disperse when salinity is reduced by flood irrigation. Gypsum dressings, wetting and drying cycles, waterlogging and the growth of roots and micro-organisms are shown to affect soil structure, and reasons for these effects are stated. Certain common pasture species are adaptable to poorly aerated soils.

Introduction

The soils of the Riverine Plain of South-Eastern Australia (Butler, 1950) belong to a halomorphic sequence. Salt accumulated during a previous period of aridity and intermittent stream flow. In more recent times increasing rainfall has caused slow leaching of this salt (Butler, 1950). As salinity is reduced the soil colloids tend to dissociate, the degree of dissociation chiefly depending on the nature and amount of exchangeable cations present. If more than 12 per cent. of the cation exchange capacity is taken up by the ions of sodium and potassium, then in most cases dissociation and hydrolysis will be appreciable, pH will rise and the colloids will disperse. De Sigmond (1927) classified all soils with greater than 12 per cent. $Na^+ + K^+$ saturation of the cation exchange material as alkali soils. Most soils of the Riverine Plain irrigated for pasture production belong to this group. The percentage $Na^+ + K^+$ saturation of three types is given in Table 1.

Flood irrigation greatly increases the rate of leaching of salts and changes the soil profile to a less permeable (solodous) type. Working at Deniliquin, Sinicins (1950) found that 8 irrigations totalling 14 inches of water, plus rainfall, had removed half the total soluble salts from the first foot and a third from the second foot of a clay soil (Type R, F.M.F.S.).* pH (1:5 suspension) increased at both depths. During a single rice-growing season 40 per cent. of the soluble salts was leached from the 0-30 inches depth of this soil. pH (1:5) increased, reach-

TABLE 1

$Na^+ + K^+$ per cent. of total exchangeable cations

Soil Type	Depth ins.	$Na^+ + K^+$ per cent.
Wakool loam	0-5	22
	5-16	22
Yallakool clay loam	0-2	26
	2-20	31
Soil type R, Falkiner	0-½	19
Memorial Field Station	3-10	27

Source:—
C.S.I.R. Bull., 162, 1943.
Ann. Rept. 1949/50, C.S.I.R.O. Reg. Past. Lab., Deniliquin.

*Soil type R is an illitic clay with little structural development below 8 inches. Traces of lime occur below 12 inches and 0.1 to 0.8 per cent. of gypsum occurs below 30 inches. Total soluble salts increase from 0.1 per cent. in the top 3 inches to 1.7 per cent. in the 21 to 30 inches depth. Percentage saturation data are given in Table 1.

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ing a maximum of 8.6 in the 12-21 inches depth.

Rapid dispersion of the soil colloids during flood irrigation leads to the formation of surface seals, and brairding percentages of species germinated by irrigation are very low. In the fine-textured horizons air space within the macro-aggregates at field capacity becomes negligible, and root distribution tends to be restricted to cleavage faces.

A strongly developed, water-stable structure is likely to be built by:—

1. replacing most of the exchangeable sodium ions with calcium,
2. assisting the thorough penetration of the soil by plant roots and the growth of associated micro-organisms.

The effects of wetting and drying cycles, and of a prolonged period of inundation, as opposed to intermittent irrigation, are also of importance.

Cation Exchange

Flocculated clays will not readily disperse when the salinity of the soil solution decreases, if calcium is the dominant cation in the exchange complex and if the proportion of exchangeable sodium and potassium is low. Thus the addition of calcium salts may prevent structural breakdown during irrigation.

On soil type R near Deniliquin, gypsum at 2 and at 8 tons per acre was cultivated into the top two inches of a virgin site before sowing and inundating a rice crop. The gypsum plots remained mealy and moist at the surface after irrigations, but untreated plots slaked to form a rapidly drying crust. The treatments improved rice seedling establishment by 50 per cent. After a three months period of inundation it was found that resistance to penetration of a 0.5 inch diameter probe and the apparent density of the surface soil were lower on the gypsum plots than on the nils. Observations of the cracking pattern of dried pastes (Sinicins, 1951, unpublished data), and construction of settling velocity curves after mild dispersion, showed that gypsum at 2 tons per acre reduced dispersion in the 0-3 inches depth, and at 8 tons per acre dispersion in both 0-3 and 3-12 inches depths. Gypsum, at 2 tons per acre, had reduced pH in the 0-3 inches depth, although total soluble salts were not increased. At the 8 tons per acre rate, pH had been reduced in the 0-3 inches and 3-12 inches depths and total soluble salts had been increased. A considerable part of the response at the heavier gypsum rate is due to the flocculating effect of the additional salts present in the surface foot, and the response may be expected to diminish as the excess is leached down. Measurements of these differences are shown in Table 2.

Gypsum may also be applied in solution in irrigation water. Sinicins found that

TABLE 2

Differences between plots of Soil Type R inundated in the presence and absence of Added Gypsum

Gypsum tons/acre	pH		Soluble Salts		Apparent Density	Probe
	0-3 ins.	3-12 ins.	0-3 ins.	3-12 ins.	0-3 ins.	Penetration
			gms. per 100 gms.		gms. per cc.	ins.
NIL	7.22	8.01	0.035	0.059	1.27	19.8
2	6.83	7.93	0.042	0.044	1.25	24.0
8	6.55	7.60	0.227	0.080	1.21	25.6
Diff. for Significance	0.15	0.17	0.104	0.027	0.03	2.8

clay from soil type R flocculates and settles from 1:5 :: soil : water suspension within two hours providing that the gypsum concentration exceeds 0.04 per cent.

In considering the possible effects that rice growing could have on soils of the Wakool Irrigation District, Butler (1951) reminds us that gypsum frequently fails to ameliorate intensely solodised soils, since its solubility and penetration are limited and since reduction of hydrolysis does not, in itself, produce aggregation. He suggests that it may be possible to regrade these soils by the application of a mixture of common salt and gypsum, followed by leaching, provided that a sufficiently high calcium/sodium ratio is maintained.

Wetting and Drying Cycles

Illite dominant alkali clays such as soil type R undergo large volume change with change in soil moisture. Shrinkage during drying produces numerous cracks, which provide sites for brairding and for root penetration. Most seedlings established on soil type R by flood irrigation emerge through shrinkage cracks in the surface seal. The roots of white clover, strawberry clover and perennial ryegrass tend to be confined to cleavage faces in horizons with small pores, and fail to penetrate subsoils unless suitable cleavages are present. Cracking patterns developed in the top foot of soil are greatly modified by plant growth, which causes the cracks to be more widely spaced, and which reduces the separation of surface crusts from the body of the soil. Surface shading by top growth and water absorption from numerous foci by roots cause more even drying of the soil mass, and the binding action of roots resists the stresses developed during shrinkage. The cracking pattern of soil type R after inundation and drying in the absence of plant cover is shown in Figure 1, and is contrasted with the cracking pattern of soil type R after growth of a rice crop and drying as shown in Figure 2.

A succession of wetting and drying cycles breaks up the surface of soil type R into small clods and greatly reduces the hardness of these clods. The structure so produced is, however, unstable to water, and the soil will quickly revert to and remain in a massive condition during brairding and the growing season, when it must be kept moist.

Waterlogging

Soil structure is affected differently by a prolonged period of inundation than by intermittent irrigations. Soil type R, in-

Figure 1.
The cracking pattern of soil type R after inundation and drying in the absence of plant cover.

Figure 2.
The cracking pattern of soil type R after inundation and drying in the presence of a rice crop.

Figure 3.
The surface condition of summer inundated plots three months after cultivation and sowing with Wimmera ryegrass/subterranean clover.

Figure 4.
The surface condition of virgin plots three months after cultivation and sowing with Wimmera ryegrass/subterranean clover.

undated from late December until early March, and subsequently cultivated and sown with Wimmera ryegrass/subterranean clover, remained granular at the surface, while virgin soil, similarly cultivated and sown, slaked down under the action of winter rains. Figure 3 shows the surface condition of summer inundated plots three months after sowing with Wimmera ryegrass/subterranean clover. The surface of virgin plots three months after sowing with Wimmera ryegrass/subterranean clover is shown in Figure 4.

The surface inch of the summer inundated plots contained more water-stable crumbs than the surface of the virgin plots, despite its lower content of soluble salts. The stability of these crumbs may be due to reduction and solution of iron oxides during inundation, with transport to and oxidation at root surfaces and at aggregate surfaces during drying. Deposits of ferric compounds were observed bordering root channels and on cleavage faces. The partial decomposition products of a surface accumulation of algae may also have acted as cementing agents. Their effect would be unlikely to last for more than a few months.

The Effects of the Growth of Roots and Micro-organisms

Swaby (1949a) has demonstrated the powers of fungi to produce water-stable aggregates. Plots at Deniliquin which had grown a rice crop before being sown to Wimmera ryegrass/subterranean clover remained cloddy during the winter and a growth of fungi could be seen on the roots and disced-in straw of the rice crop. It is presumed that hyphal binding of the soil particles contributes to the stability of the surface structure on these plots.

Swaby (1949b) also demonstrated that the ramification of grass roots through the soil fails to increase water-stable aggregation in the absence of micro-organisms, but, under normal non-sterile conditions of growth, aggregation is rapidly increased. The growth of roots and their associated micro-organisms through a soil is a more effective means of increasing water-stable aggregation and pore space than the addition of large amounts of organic manures (Martin, 1944). Root growth continuously supplies organic matter to micro-organisms, and thoroughly intermingles it with the soil. Organic manuring causes feast then famine and distribution is clumpy.

The root growth of rice is frequently credited with the power of opening up the surface of fine-textured clay soils. However, Deniliquin experiments with this crop on soil R showed no difference in apparent density between clods taken from under a rice crop and clods from soil which had been inundated but not sown. Although 30 cwt. per acre of oven dry roots had been produced by the crop, the net addition of macro-organic matter* to the soil was only 6 cwt. per acre, root accretion having been balanced by the decomposition of plant residues present in the soil before the inundation period. The changes are described in Table 3.

TABLE 3

Oven Dry Weight of Macro-organic Matter, cwt./acre, 0-30 inches

Treatment	Cwt./acre
Cultivation	59
Cultivation + Inundation	36
Cultivation + Inundation + Rice	65

Important species differences exist in the ability of roots to penetrate horizons in which pore size is small. The roots of paspalum and of *Panicum coloratum* are better able to penetrate such horizons than are the roots of perennial clovers and of perennial ryegrass. The root system of one year old *Panicum coloratum* grown on a poorly structured clay loam is shown in Figure 5. This may be contrasted with the shallower root system of perennial ryegrass shown in Figure 6. The roots were exposed by washing soil from prisms of 8 x 3 inches cross-section and 18 inches depth.

Some data have been obtained at Deniliquin of the surprisingly large weights of macro-organic matter which accumulate below dense swards of irrigated perennial pasture on a coarser textured soil than that described earlier in this paper. Three year-old pastures grown on soil type B† had accumulated from 8 to 14 tons per acre of oven dry macro-organic matter, the concentration sharply decreasing with depth. Concentration by weight was fifteen times greater in the top 3 inches than in the 9-18 inches depth. From one-half to three-quarters by weight of the macro-organic matter occurring from 0-18 inches was found in the top 3 inches. Data for three pastures are given in Table 4.

Pastures differ in their effects on soil structure. Friability and water-stable aggregation > 1 mm. were found to be greater under cocksfoot/white clover than under perennial ryegrass/white clover or lucerne/perennial ryegrass grown on soil type B. Cocksfoot has a finely ramifying root system, with numerous shortly branched laterals of smaller diameter than those of ryegrass.

For any one pasture as the concentration of macro-organic matter in the 0-3 inch depth increased infiltration rate decreased, possibly due to increasing occupation of soil pore space by roots. By using a regression established between macro-organic matter concentration and infiltration rate, the effects on infiltration rate of pastures of different quality were compared at a common soil macro-organic matter concentration. Thus, the three-year-old lucerne dominant pasture was found to have a lower infiltration rate than co-dominant perennial grass/white

*This term is used to describe the separate obtained by centrifuging a suspension of soil in salt solution of ρ 1.2 gm./cc., and filtering the supernatant through Whatman 50 papers. The separate is made up of coherent organic particles of diameter $> 2\mu$.

†Soil type B is a brown solonetzous sandy loam with a bleached compacted horizon at 9-13 inches, overlying a clay with moderately developed coarse structure. For the purpose of this discussion its major difference from soil type R is its coarser textured surface.

Figure 5.
The root system of *Panicum coloratum*
Grid = 3 in. by 3 in.

Figure 6.
The root system of perennial ryegrass
(*Lolium perenne*)
Grid = 3 in. by 3 in.

TABLE 4

Dry-Weight of Macro-organic Matter 0-18 *ins., and Percentage Distribution with Depth*

Soil Type B	Phalaris/White Clover	Perennial Ryegrass/White Clover	Lucerne/Perennial Ryegrass*
Weight of Macro-organic matter 0-18 ins. tons/acre	11.8	12.4	8.4
Percentage at 0-3 ins.	63	73	53
Percentage at 3-9 ins.	20	19	35
Percentage at 9-18 ins.	17	8	12

* Lucerne dominant.

TABLE 5

Infiltration Rate, Inches per Hour, at a Common Macro-organic Matter Concentration of 1.5 *per cent. at* 0-3 *inches—Soil Type B*

Paspalum/ White Clover	Phalaris/ White Clover	Perennial Ryegrass/ White Clover	Cocksfoot/ White Clover	Lucerne dominant	Diff. for signif. P.05
2.3	1.9	1.8	1.6	0.7	0.7

clover pastures at a common macro-organic matter concentration of 1.5 per cent. in the 0-3 inch depth. The greater proportion of bare space exposed in the lucerne dominant pasture may have permitted greater structural deterioration. The cocksfoot/white clover pasture had a lower infiltration value than the paspalum/white clover at a common macro-organic matter concentration in the 0-3 inch depth. Cocksfoot has the finest and paspalum has the coarsest root system of the grasses examined. Infiltration values are given in Table 5.

Selection of Pasture Plants for Badly Aerated Soils

Prunster (1950) has put forward the concept that irrigated solodous soils may be regraded by firstly establishing those species which possess some degree of hydrohytism, and which would enable, through the soil changes associated with their growth, the subsequent establishment of standard pasture species as the climax community of the hydrosere.

Some common pasture species are, however, tolerant of poorly aerated soils, and they may be grown successfully on virgin soils, provided that the irrigation design permits reasonably fast and even removal of surface water. Species trials in progress at Deniliquin use the critera of yield on an unimproved solodous soil, and the ratio of yield on the unimproved site to yield on a site improved with regular dressings of gypsum and sheep manure. Wimmera ryegrass and *Phalaris aquatica* are promising grasses on the unimproved soils. These grasses, together with the Clare and Yarloop strains of subterranean clover, have yield ratios close to unity during the winter period. Yield ratios of the early maturing medics and vetches are low, but the ratios approach unity for the later maturing strains, which make most of their growth after aeration has improved.

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TECHNICAL NOTES

FUSARIUM FOOT ROT OF CUCURBITS IN NEW SOUTH WALES

This note records the occurrence in the field in New South Wales of Fusarium foot rot of *Cucurbita maxima* Duch. (pumpkin) and *C. pepo* L. (squash and marrow) and also reports the result of glasshouse and field tests on varietal reaction in five genera and seven species of the botanical family *Cucurbitaceae.*

Previous Records and Occurrence in New South Wales

A Fusarium foot rot of *Cucurbita* (Tourn.) L. was first recorded in South Africa (Doidge and Kresfelder, 1932), the causal organism being determined as *F. javanicum* Koord. var. *theobromae* (App. et Strk.) Wr. (*F. javanicum* Koord.) (Wollenweber and Reinking, 1935). Snyder (1938, 1940) recorded in California a foot rot of *C. maxima, C. moschata* Poir. and *C. pepo* caused by a species of *Fusarium* which agreed morphologically with *F. javanicum.* In their revision of the section *Martiella* of the genus *Fusarium,* Snyder and Hansen (1941) designated the pathogen *F. solani* (Mart.) App. et Wr. form *cucurbitae* Snyder and Hansen, synonym *F. javanicum.*

A foot rot of *C. maxima* and *C. pepo* has been recorded in New South Wales on a number of occasions since 1947 (N.S.W. Dept. Agr. Biol. Branch Ann. Repts. 1947, 1950, 1951, 1952).* In each case the symptoms agreed with those described by Doidge and Kresfelder (1932), Snyder (1938) and Gries (1946) (see Figures 1 and 2) and a species of *Fusarium* was isolated which agreed morphologically with *F. solani* form *cucurbitae.* Glasshouse inoculations reproduced the disease and an isolate was forwarded to Dr. W. C. Snyder at the University of California, who confirmed the identification (Snyder, 1951).

The economic importance of the disease in New South Wales would appear to depend primarily on the amount of infected seed distributed. The first record of the disease was made by Dr. L. R. Fraser, of this Department, in the Man-

Figure 1.
Field symptoms of Fusarium foot rot of White Bush Scallop squash. Compare with surrounding healthy plants.

*A recent examination of an exsiccatus showed that Fusarium foot rot had occurred on a pumpkin on the north coast of New South Wales in 1923.

ning River area of the central North Coast, this being one of the cucurbitaceous seed producing areas. A survey of the area by the author in January, 1953, revealed that the disease has occurred sporadically in crops of pumpkin, squash and marrow over the last ten years, sometimes causing appreciable losses to the individual seed producer. Up to 30 per cent. seed infection, of which 7 per cent. was internal, has been detected in seed lots of pumpkin (var. Queensland Blue). Other seed samples of this variety of pumpkin have also been found to be carrying the fungus and some of the outbreaks of this disease in crops of *Cucurbita* spp. in this state have been traced to the planting of infected seed.

Varietal Reaction to Fusarium Foot Rot

In the botanical family *Cucurbitaceae,* Fusarium foot rot has been recorded occurring naturally only on the genus *Cucurbita.* Snyder (1938) noted that the Italian Zucchini squash was particularly susceptible. In Connecticut, foot rot was almost entirely limited to yellow summer squash and the progeny of crosses involving this as one of the parents (Gries, 1946). In inoculation tests Prasad (1949) found marked differences in the pathogenicity of 33 strains of *F. solani* form *cucurbitae* when tested on *C. pepo* (var. Black Zucchini), degrees of pathogenicity from very virulent to non-parasitic being shown to exist among the strains.

In inoculation tests Doidge and Kresfelder (1932) showed that watermelon (*Citrullus vulgaris* Schrad) var. Ice Cream and cucumber (*Cucumis sativus* L.) var. White Spine were susceptible to the disease, cucumber, however, being somewhat less susceptible than pumpkin, marrow or watermelon. Prasad (1949) states that some of the more pathogenic strains of the fungus were capable of attacking watermelon.

An isolate of the fungus obtained from infected squash plants in the Manning River area was used in a series of inoculation tests to determine the reaction of various cucurbit varieties. Single spore cultures, grown on corn sand medium (Riker and Riker, 1936), in $\frac{1}{4}$-pint milk bottles were incorporated in flats of sterilized soil containing up to 10 seedlings of the varieties under test. A

Figure 2.
Fusarium foot rot of marrow plant showing typical rotting of the lower stem. Note that the roots are relatively unaffected.

parallel series of tests were also conducted by planting seed in infected outdoor soil. In all, five series of tests were conducted.

The results of the tests showed that varieties of pumpkin, squash, marrow, watermelon and citron (*Colocynthis citrullus* (L.) Kuntze) were very susceptible to Fusarium foot rot. Varieties of rockmelon (*Cucumis melo* L.) and cucumber generally proved less susceptible to the disease but there was evidence of variation in susceptibility among individual varieties of these two plants. Choko (*Sechium edule* (Jacq.) Sw.) was not susceptible to the isolate used in the tests.

The following varieties were tested.

Pumpkin:—Golden Hubbard, Green Warted Hubbard, Queensland Blue, Triamble, Turks Cap High Crown.

Squash:—Custard, Early White Bush, Pink Banana, White Bush Scallop.

Marrow:—Long Cream Running, Long Green Running, Long White Running, Roller, Zucchini.

Watermelon:—Angelo, Blacklee, Cannon Ball, Early Canada, Early Kansas, Hawkesbury Wilt Resistant, Kleckley Sweet, Klondyke, Market Wonder, Stone Mountain, Tom Watson.

Citron:—Red Seeded.

Rockmelon:—Benders Surprise, Californian Cream, Hales Best, Improved Yellow Cantaloup, Jade Beauty, No. 5 Cantaloup, P.M.R. 45, Rocky Ford, Texas Resistant No. 1.

Cucumber:—A and C, Apple Shaped, Crystal Apple, Early Fortune, Kirby Staygreen, Long Green, White Spine.

Acknowledgments

The author is indebted to Dr. L. R. Fraser, Plant Pathologist of this Department, for making available a culture of the fungus and also unpublished data from a varietal test; and to Mr. A. C. Orman, Principal Agronomist (Vegetables) of this Department, for advice on varietal nomenclature.

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A PASTURE OVERSEEDING IMPLEMENT

Investigations by the Faculty of Agriculture, University of Sydney, into the problem of increasing pasture productivity on the red-basaltic soils of the Richmond-Tweed region (New South Wales), were commenced in 1950.

The predominant pasture species is *Paspalum dilatatum* and white clover (*Trifolium repens*) is the only leguminous pasture species occurring in quantity. The latter behaves as an annual; in all but favoured areas, it is not present in the sward during the summer months, nor is it a conspicuous component at any time of the year. Applications of lime and superphosphate to the pastures have had little effect on productivity.

The approach to the problem by the Faculty has proceeded along four main avenues of research:—

1. Methods of seeding leguminous pasture species into the Paspalum sward.
2. Behaviour of different leguminous species in the environment.
3. Response by legumes to combinations of fertilizers.
4. Studies of effectiveness of strains of *Rhizobia* and of different methods of inoculation.

Practical application of results obtained from the latter three lines of investigation will depend to a large degree on the efficiency attained in the method of seeding.

An implement has been constructed which places inoculated seed with fertilizer into the soil immediately beneath the uncultivated Paspalum sod.

Overseeding of legumes into gramineaceous pastures in Australia has been conducted on an extensive scale with the standard seed and fertilizer combine. Callaghan (1949) and Roe (1951) have recorded satisfactory establishment of clover plants amongst an existing sward of native grasses of a tufted habit by this method.

Since our investigations commenced, Blackmore (1952) has described the performance by a seed drill, fitted with "grassland" tips. This implement has given good results in tussock grassland in New Zealand.

The standard Australian combine was first used for overseeding the Paspalum pastures but even when fitted with special chisel-edged shoes, penetration was unsatisfactory. Initial trials with this implement did demonstrate however, that where penetration was effected, germination of clovers was good.

The implement, illustrated in Figure 1, was constructed for seeding in 1952. Apart from the features indicated numerically it incorporates:—

(a) provision for range in tyne spacing;

(b) synchronization of ground wheel with lifting of the implement, by chain, giving automatic release and engagement of seed and fertilizer delivery through operation of the hydraulic control;

Preliminary trials with this implement have given encouraging results. Germination of species seeded into Paspalum swards has been good. Placement of seed

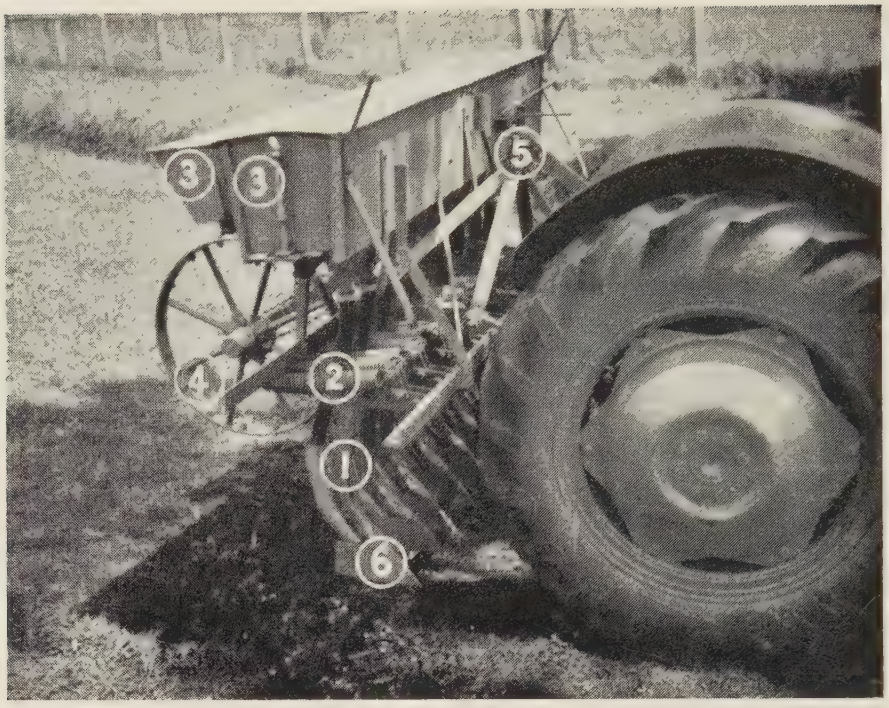

Figure 1.
LEGEND.

1. rigid tynes.
2. spring-loaded stump-jump principle (300-lb. pressure for release);
3. fertilizer and small seeds' boxes mounted by stays on the tiller chassis;
4. ground wheel driving seed and fertilizer delivery through a chain and sprocket system;
5. hydraulic control from the tractor;
6. seeding shares with penetrating points and wings to hold back sod and soil until seed and fertilizer have fallen to the full depth of penetration.

and fertilizer is positive and an even depth of penetration can be maintained. Clearance of surface trash from the tynes is quickly effected, when necessary, by operating the hydraulic lift. Being mounted on the tractor, the implement is far superior in mobility to a drawn combine or drill.

We believe that the implement may be of use for overseeding certain pasture areas which cannot be traversed or penetrated by combines and seed drills.

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A MODIFIED SKETCHMASTER FOR SOIL MAPPING

A sketchmaster, produced by P. S. Sharman and Co., Melbourne, has been used very successfully for transferring soil boundaries from aerial photographs to the base plan. Small alterations of scale can be made but its greatest use is in overcoming edge distortion when fitting the photographs to the plan. The further distortions caused by variations in land-surface heights can also be rectified by suitably tilting the sketchmaster.

To make working more accurate and less tiring, modifications were made to the instrument. These were necessary because of the similarity in colour of photograph and pencil point.

An enclosing canopy shielded the photograph from all external light and a 6V 24W motor car headlamp bulb was fitted to illuminate the photograph. Illumination must be indirect by reflection from the shiny internal faces of the canopy and the mirror, so a light baffle was fitted near the bulb. The bulb was connected to the mains through a Variac resistor.

By increasing the resistance the plan and pencil point could be seen more clearly and by decreasing the resistance the photograph is highlighted.

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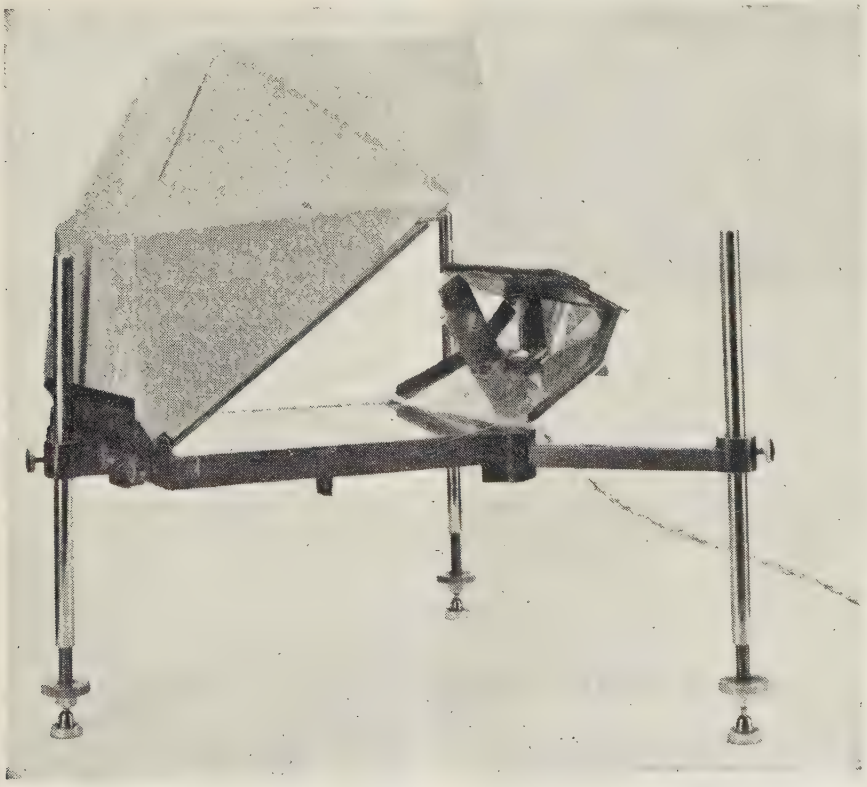

Figure 1.
The modified Sketchmaster showing the canopy and the light baffle fitted. The canopy drops down to hold the photograph in place on the glass plate.

THE AUSTRALIAN MEDAL OF AGRICULTURAL SCIENCE

1953 AWARD TO D. S. RICEMAN

The award of the Australian Medal of Agricultural Science for 1953 was announced by Council to the 20th General Meeting, held in Adelaide on 23rd March, 1953. The medal was presented to the recipient, D. S. Riceman, B.Ag.Sc., M.Sc., by Prof. E. J. Underwood, retiring President and winner of last year's award.

Mr. Riceman is now Principal Research Officer, Plant Nutrition Section of the C.S.I.R.O. Division of Biochemistry and General Nutrition, Adelaide. Apart from a period of war service with the A.I.F., he has been with that Division, or its forerunner, the Division of Animal Nutrition of C.S.I.R.O., since 1935.

During recent years, Mr. Riceman has conducted investigations which have provided a sound basis for the successful development of a huge tract of country in South Australia where, previously, economic agriculture was impossible.

The work during the period for which the Award was made has been concerned with the large area of near-virgin soils in the upper south east of South Australia. In a series of long term experiments, Mr. Riceman has made detailed studies of plant species and added fertilizers on representative soils throughout the area. Results of these experiments have clearly demonstrated the importance of zinc and copper, in addition to phosphate.

As the outcome of this painstaking and detailed work, information has been obtained on a wide variety of problems, including:

(a) the differential response of lucerne, phalaris, oats and strains of subterranean clover to various amounts of phosphate, zinc and copper;

(b) the rate and frequency of application of phosphate, zinc and copper for the correction of their deficiency in representative soils;

(c) the effect of zinc and copper on the growth and seed production of subterranean clover and oats; and

(d) the influence of cover crops, including legumes, upon the establishment of pasture species in new land and upon the fertilizer requirements of the pasture.

HONORARY LIFE MEMBER — Dr. G. L. SUTTON

The award of Honorary Life Membership in the Australian Institute of Agricultural Science to Dr. G. L. Sutton comes as a fitting tribute to a career of splendid service to Australian agriculture.

George Lowe Sutton was born in 1872 at Liverpool, England, and came to New South Wales in 1882. After obtaining first class honours in agricultural science at the Sydney Technical College he was appointed Experi-

mentalist and Lecturer at the Hawkesbury Agricultural College.

The young experimentalist at Hawkesbury College was very interested in the testing of the new crossbred wheats developed by Farrer. He had himself initiated comparative yield trials with maize varieties at the college and was probably the first to use the "control" or "standard variety" as the yardstick for measuring the relative production of a number of strains. This technique is now used in all experimental work of this type.

Following Farrer's death at Lambrigg in 1906, the responsibility for supervising the wheat breeding activities and cereal trials of the New South Wales Department were transferred to Mr. Sutton, who had been appointed manager of the Cowra Experiment Farm. He was responsible, not only for the organization of a scheme for distributing the Farrer wheats to farmers but also for the commercial success of varieties such as Federation and it was largely due to his efforts that Farrer's ideals and objectives were not forgotten.

Mr. Sutton joined the Western Australian Department of Agriculture in 1911 and was soon appointed Commissioner of the Wheat Belt. One of his earliest and most far-reaching decisions was to urge the retention of the various State Farms which he renamed Experiment Farms and later Research Stations. These were at first used exclusively for experiments with wheat but gradually their character changed and scope widened until their activities included almost the whole field of agriculture.

From the beginning Mr. Sutton insisted upon sound experimentation and he was among the first to recognise the importance of the long narrow plot in field experiments and the need for adequate replication to obtain reliable data. With the "three-plot system", which he introduced, a range of experiments on time of planting, rate of seeding, rate of superphosphate application and depth and frequency of cultivation was carried out at the Experiment Farms. The results of these experiments, together with variety trials, gave clear-cut answers to many of the practical problems of wheat farmers and enabled the development of sound agricultural practices throughout the Western Australian wheat belt.

Side by side with this important work proceeded the wheat breeding activities, for which Mr. Sutton is best known and which yielded results of such importance, not only to Western Australia but to the Australian wheat industry as a whole. From the early generation crossbred material brought by him from New South Wales the outstanding varieties "Nabawa", "Geeralying" and "Carrabin" were produced. "Nabawa" was among the first rust-resistant varieties produced in Australia and retained its resistance until 1925 when a new race of rust appeared in Western Australia. When it was found to be almost immune to flagsmut it rapidly became the most extensively grown wheat in Australia. This triumph was later

repeated with the variety "Bencubbin" produced at the Merredin Experiment Farm in 1930.

These activities followed naturally from Mr. Sutton's work in New South Wales but upon becoming Director of Agriculture in Western Australia in 1921 he proceeded to organize the whole department upon an equally sound basis. He had an immense faith in the scientific approach to practical problems and in the value of scientifically trained men. He instituted a system of cadetships to enable young men to be trained at the university for subsequent employment as advisory officers and specialists in the Department of Agriculture. This progressive policy paid immense dividends in the creation of a department very largely staffed by university graduates and is regarded by many as his major contribution to Western Australian agriculture.

As a mark of appreciation of these great services the University of Western Australian conferred upon him, upon his retirement in 1937, its first and only honorary degree of Doctor of Science in Agriculture. Retirement for Dr. Sutton has not meant, however, a life of ease and leisure but one of continued activity in the interests of agriculture. He has remained Chairman of the Dairy Products Marketing Board and of the Merchants Agricultural Research Trust and has devoted unflagging energy and enthusiasm to two lifelong interests—the marketing of wheat and the improvement of our daily bread. This valuable work is still going on and will, it is hoped, continue for many years to come.

ANNUAL REPORT OF COUNCIL

Report of Council to the 20th General Meeting held at Adelaide on March 23rd, 1953.

Ladies and Gentlemen,

Your Council has pleasure in presenting its Report for the year ending December 31, 1952, which is the seventeenth year of Institute activity.

Office bearers for the year have been:

President	Professor E. J. Underwood.	
Hon. General Secretary	Mr. G. A. McIntyre.	
Hon. General Treasurer	Mr. A. V. Hill.	
	Delegate	Proxy
New South Wales Branch	Dr. S. L. Macindoe	Mr. C. M. Donald
Victorian Branch	Mr. L. R. Hoult	Mr. K. Loftus Hills
Queensland Branch	Mr. P. J. Skerman	Mr. W. M. Willoughby
South Australia Branch	Dr. R. N. McCulloch	Mr. C. H. Williams
Western Australian Branch	Mr. A. J. Millington	Mr. F. O. Grogan
Australia Capital Territory Branch	Mr. C. S. Christian	Mr. C. Neal Smith
Tasmanian Branch	Mr. T. D. Raphael	Dr. C. Barnard

Council met on eight occasions during the year, the President chairing three of them.

Eighteenth General Meeting

The Eighteenth General Meeting was held at Canberra on March 27, 1952, for the transaction of the formal business of the Institute. Reports were adopted and amendments to articles to create a class of emeritus membership were accepted.

Nineteenth General Meeting

The Nineteenth General Meeting was held at Science House, Sydney on August 18, 19, 1952 in conjunction with A.N.Z.A.A.S. All Branches except Tasmania were represented by Principal Delegates. Among matters discussed by the meeting were agricultural engineering, the A.I.A.S. Scholarship Scheme, Institute Text Book, Affiliates, Rural Extension ideals. The meeting was followed by an Institute Dinner at which was given the Presidential Address.

Agricultural Engineering

There was a lull in interest in this issue until a paper by G. H. Vasey was read at the 19th General Meeting. Following this, a variety of opinion has been offered by branches and it will be the function of the incoming Council to decide on what action if any should be taken. Two articles are in preparation by Mr. Vasey for publication in the Journal.

Rural Extension

Following the distribution of the Institute survey of rural extension in Australia, there was no support from the State Departments for the principal recommendation that a qualified person with overseas experience should examine the position in all states. The further recommendation that the Institute should formulate ideals for the type of person engaged in this occupation, the scope and form of departmental service and the type of training best suited to fit a man for the occupation has been acted upon and the first two phases of the enquiry are virtually finalized. Mr. F. Grogan and Mr. R. Sherwin have now retired from the project and a new Council Sub-Committee has been appointed to deal with the third phase.

Affiliates

It was clear after much discussion that no qualifications bar could be applied to this proposed class and that it would be the responsibility of the branches to maintain standards and regulate the duty of such persons. It was proposed that the fee should be the same as for corporate members. A set of articles embodying these ideas was voted on at the 19th General Meeting and was adopted by a narrow majority. The Queensland delegate requested that a postal vote be taken on the amendments. The result of this vote was the rejection of the amendments.

A.I.A.S. Scholarship Scheme

The most suitable field for the granting of a scholarship is undoubtedly in the honors year of the Agricultural Science Course. However, money donated for scholarships to meet this need would not be allowed as a tax deduction to the donor. In view of this and the current abundance of scholarships in the postgraduate field and the difficulties of maintaining the collection of funds to sustain one or more scholarships of adequate value, it was decided at the 19th General Meeting to drop the project, at least for the time being.

A.I.A.S. Journal

The quarterly issues of the Journal were published on schedule and the Publications Committee is to be congratulated on maintaining a high standard. The review articles in particular have been very favourably commented on and it is hoped that this series can be sustained, together with greater support by members in contributing technical articles. The development of the news item section, primarily as a result of the efforts of the Assistant Editor, has added considerably to the local interest in the Journal.

Mr. N. M. Tulloh retired from the office of Hon. Editor in August after a period of very active and fruitful endeavour. Council is fortunate in the appointment of Mr. J. M. Stevens to succeed him.

Members of the Publications Committee during 1952 were:

Hon. Editors	N. M. Tulloh, J. M. Stevens
Hon. Assistant Editor	P. F. Butler
Hon. Business Manager	J. S. Orr
Hon. Asst. Business Managers	P. M. Dexter, I. McL. Eadie
Committee Members	R. D. Croll, J. A. Baker, H. C. Forster, N. S. Noble, H. G. Turner.

Interchange of Superannuation Rights

A statement collating correspondence from Commonwealth and State Governments and prepared by the Secretary of the Joint Standing Committee of Scientific Bodies was distributed to branches. No positive action by the Institute was commended other than a recommendation to the Standing Committee that it continue to press for uniformity.

Commonwealth Bank Rural Credits Grant

In response to a request from Council for financial assistance towards meeting the cost of the Journal, the Commonwealth Bank very generously donated £200 for the year 1952-53. Council is extremely pleased with this tangible evidence of appreciation of the service of the Institute towards the scientific development of agriculture in Australia.

Text Book

A preliminary report on the possibility of the Institute sponsoring a text book of a general character or a series of specialist texts was made by Mr. P. J. Skerman at the 19th General Meeting. It was decided that, in view of impending publications by local publishers on specific agricultural subjects, the field most suitable for Institute effort would be a general text on the farmer or agricultural college level.

Progress has been made since this meeting towards defining the contents in detail and securing the co-operation of Institute members to participate in the work. It is expected a decision will be made shortly on whether to proceed with the proposal or not.

Australian Medal of Agricultural Science

The fifth award of the medal was made to Professor E. J. Underwood for his contributions in the field of animal nutrition and agricultural education. The medal was presented at the 18th General Meeting.

Membership

Corporate Membership

	N.S.W.	Vic.	Q'ld	S.A.	W.A.	Tas.	A.C.T.
As at 31/12/51	236	262	96	116	117	35	58
Admissions	24	30	13	5	4	6	3
Transfer gains	—	3	2	1	1	2	5
Transfer losses	7	1	1	5	—	2	2
Resignations	5	3	1	2	1	1*	1
Terminations	3	—	1	—	—	—	1
Deaths	4	1	—	—	1	—	—
As at 31/12/52	241	290	108	115	120	40	62

Total all branches 976.

Student Membership

	N.S.W.	Vic.	Q'ld	S.A.	W.A.	Tas.	A.C.T.
As at 31/12/51	114	37	37	19	50	—	—
As at 31/12/52	82	17	28	20	47	—	—

Total all branches, 194.

Emeritus Membership

Admitted during 1952.

New South Wales	3
Tasmania	1
Death, New South Wales	1
As at 31/12/52	3

Institute Publicity

Members of the South Australian and Victorian Branches have contributed as members to newspaper productions associated with the Royal Agricultural Shows and have effectively brought the Institute before the notice of the public. In addition branch funds have been strengthened by this most praiseworthy effort.

Qualifications Committee

During 1952 the Qualifications Committee continued its valued service to the Institute by the scrutiny of all applications for corporate membership. The Committee consisting of Dr. E. T. Edwards (Convenor), Mr. F. C. McCleery and Professor J. R. A. McMillan retired at the end of 1952 after a term of office of three years. The Convenor of the incoming committee is Mr. W. W. Bryan with Professor L. J. H. Teakle and Mr. C. H. Winders as associates.

Financial Statement.

A statement of income and expenditure over the past two years is given in the following table.

Expenditure	1951	1952
Journal Loss	£626	£938
Rebates on Subscriptions	—	458
All travelling expenses	161	277
Typing, Stamps and Sundries	204	189
Audit Fee	16	19
Legal Expenses	12	10
Honoraria	—	6
Branch Grant	30	—

Income	1951	1952
Subscriptions	£876	£1580
Interest on Bonds	29	29
Grant		200
Excess of Expenditure over Income	144	90
Subscriptions in Arrears	312	942

This is the first year with subscriptions at double previous rates and even taking into account the normal lag in collection of subscriptions, the increase from £312 in 1951 to £942 in 1952 in arrears of subscriptions is too great. This factor, taken in conjunction with the increase in cost of the Journal from £620 to £938 and travelling from £161 to £277 has been mainly responsible for the deficit of £90. The increased cost of the Journal was offset to the extent of £200 by a Commonwealth Bank grant.

Total subscriptions outstanding for the year 1952 are of the order of £750 for corporate members and £55 for students. If all subscriptions for 1952 were paid up the total would approximate £2380 and total rebates to Branches would be about £780. These estimates are probably a little high due to losses in membership and waiving of subscriptions for members overseas.

Total income, including the grant of £200 would then be in the vicinity of £2600. If Branch rebates at £780 and Journal at £938 are subtracted, the balance of £882 is available for Council expenditure. For 1952, Council expenses were £502 the biggest item being for travelling in connection with Annual Council Meetings, £277. This amount would have been increased to at least £425 if full attendances of those eligible had been obtained and all expenses were met by the Institute.

From these figures it appears that, given a full collection of subscriptions, expenditure at the present rate can be maintained. Alternatively it may be necessary to make an early review of Branch rebates and of expenditure incurred by attendance at meetings.

On behalf of the Council,

E. J. UNDERWOOD,

President.

FINANCIAL STATEMENTS

THE JOURNAL OF THE AUSTRALIAN INSTITUTE OF AGRICULTURAL SCIENCE

Statement of Receipts and Expenditure from 1st July, 1951, to 30th June, 1952

RECEIPTS.

Balance at Bank		£207	18 8
A.I.A.S. Subsidy		800	0 0
Advertising—			
Vol. 17:			
No. 1		55	12 0
No. 2		51	18 2
No. 3		57	9 11
No. 4		55	18 0
Subscriptions—			
Vol. 16		45	18 8
Vol. 17		61	9 6
Vol. 18		21	7 10
Reprints—			
Vol. 16, No. 3		5	7 0
Vol. 17—			
No. 1		22	12 5
No. 2		22	9 3
No. 3		17	15 10
Back Nos. and Vols.		11	13 8
Interest		2	16 2
		£1,440	7 1

EXPENDITURE.

Printing and Publishing—			
Vol. 17—			
No. 1		£154	2 3
No. 2		220	2 4
No. 3		232	6 8
No. 4		260	18 1
Vol. 18, No. 1		274	0 9
Advertising Rep. Commission		30	1 1
Reprints, Vol. 17—			
No. 1		26	5 6
No. 2		24	17 2
No. 3		25	4 0
No. 4		34	6 3
Exchange		1	5 0
Postage		65	9 2
Stationery		21	7 11
Audit Fee		4	4 0
Binding Vols. 15 and 16		17	3 1
Sundries		5	18 2
Balance at Bank at 30th June, 1952		42	15 8
		£1,440	7 1

Audited and found correct in terms of our Report dated 23rd January, 1953.

(Signed) CLEVELAND, SON and HISLOP,
Chartered Accountants (Aust.).

THE AUSTRALIAN INSTITUTE OF AGRICULTURAL SCIENCE.

Income and Expenditure Account for the Year ended 31st December, 1952.

EXPENDITURE

Annual Meeting—			
Travelling expenses	£80 11 0		
Typing and duplicating	54 18 9		
		£135	9 9
Audit fees		18	18 0
Council meetings — Travelling expenses		197	0 2
Journal—Loss on publication		938	4 3
Legal expenses		10	0 0
Postages, typing and sundries		134	2 0
Rebates on subscriptions		458	5 11
Honorarium		6	6 0
		£1,898	6 1

INCOME

Subscriptions Received—			
New South Wales Branch	£426 7 0		
Victorian Branch	432 16 0		
South Australian Branch	165 8 0		
Queensland Branch	251 18 0		
West. Australian Branch	136 9 0		
Australian Capital Territory Branch	131 5 0		
Tasmanian Branch	35 14 0		
		£1,579	17 0
Note: Subscriptions in arrears and unpaid at 31st December, 1952, amounted to £942/7/-.			
Interest on Commonwealth Bonds		28	12 6
Grant—Commonwealth Bank		200	0 0
Excess of expenditure over income transferred to accumulated fund		89	16 7
		£1,898	6 1

THE AUSTRALIAN INSTITUTE OF AGRICULTURAL SCIENCE.

Balance Sheet at December 31, 1952.

CAPITAL—				FIXED ASSETS—		
Accumulated Fund:				Office Furniture—at cost		£11 7 6
Balance, 31st December, 1951	£1,469 8 6			INVESTMENTS—Commonwealth Bonds		900 0 0
Less Excess of expenditure over income for the year ended 31st Dec., 1952	89 16 7			CURRENT ASSETS—		
		£1,379 11 11		Cash on hand	£10 0 5	
CURRENT LIABILITIES—				Cash at bank—		
Sundry Creditors	269 15 0			Canberra	581 2 7	
Subscriptions paid in advance	5 16 0			Melbourne	152 12 5	
		275 11 0				743 15 5
		£1,655 2 11				£1,655 2 11

THE REPORT OF THE AUDITORS.

We have examined the above balance sheet. Figures relating to the cost of "The Journal of The Australian Institute of Agricultural Science" for the period from 1st July, 1952, to 31st December, 1952, have been incorporated from statements which have not been audited. Subject to this remark, we have obtained all the information and explanations we have required, and in our opinion, such balance sheet is properly drawn up so as to exhibit a true and correct view of the state of the affairs of the Institute according to the best of our information and the explanations given to us and as shown by the books of the Institute.

COOPER BROS., WAY and HARDIE,
Chartered Accountants (Aust.).

COUNCIL PROCEEDINGS

A Council-in-Person Meeting of Council was held at the Waite Agricultural Research Institute, Adelaide, on 24th March, 1953.

Present

Dr. A. R. Callaghan (President, in the Chair); Mr. W. W. Bryan (Q'ld); Dr. K. O. Campbell (N.S.W.); Mr. C. S. Christian (A.C.T.); Mr. L. R. Hoult (Vic.); Prof. H. N. Barber (Tas.); Dr. R. N. McCulloch (S.A.); Prof. E. J. Underwood (W.A.); Mr. T. T. Colquhoun (Hon. General Treasurer) and Mr. H. P. C. Trumble (Hon. General Secretary).

Mr. J. M. Stevens, Hon. Editor of the Journal was also present.

The main items discussed were as follows:

Financial Review

The 20th Annual General Meeting of the Institute drew Council's attention to the state of arrears of subscriptions, amounting to £948. Council was most concerned about this matter and the Treasurer was asked to prepare a dissected statement, showing to what extent the Branches were in arrears.

Central Secretariat

Considerable discussion of the action to be taken in this matter was followed by a request to the Victorian Branch to prepare detailed estimates of costs.

Council Meetings during 1953-54

A programme for Council-in-person meetings was agreed upon, viz.:

August, 1953; January, 1954 (to coincide with A.N.Z.A.A.S. in Canberra); August, 1954; and January, 1955 (to coincide with A.N.Z.A.A.S. in Melbourne).

Rural Extension

A progress report was received from Professor Underwood.

Agricultural Engineering

There was some variation of opinion amongst Branches as to the action to be taken on this matter. It was finally agreed that there was need for the Institute to press for the establishment of a research and advisory centre in agricultural engineering and members are asked to proffer the support of the Institute to any such proposal wherever possible.

Proposed A.I.A.S. Text Book

This item was discussed at great length. Branch opinion was not by any means unanimously in favour of proceeding along the lines developed by Mr. P. J. Skerman and it was finally decided to appoint a sub-committee to resolve the matter. The sub-committee, consisting of the President, the Hon. General Secretary and Dr. McCulloch, was asked to examine alternative approaches and submit them to the next Council-in-person meeting.

Council agreed that the Institute should support the idea of text books sponsored by the Institute and also expressed its appreciation to Mr. Skerman for his enthusiasm and activity in connection with the text book proposal.

Branch Standing Sub-committees

The Victorian Branch presented a most interesting report setting out the objects and activities of a number of Standing Sub-committees which a Branch might appoint. Council commended this report to all Branches since the ideas contained in it offered considerable

scope for stimulating the interest of members who are not on Branch Committees.

Membership

With the recommendation of the Branch submitting the applications and the Qualifications Committee the following applications were approved:

Corporate membership: GEARD, I. D. (Tasmania).

Student membership: DIMELOW, J. B. (Victoria).

Journal

Council accepted with regret the resignations of Messrs. J. S. Orr and P. M. Dexter from the positions of Business Manager and Assistant Business Manager, respectively. To fill the vacancies created, the recommendation of the Publications Committee, that Mr. T. C. Bell and Miss B. W. Foord be appointed to the respective positions, was agreed to.

Some discussion of the balance of articles in the Journal took place and Council re-affirmed the policy at present in practice.

The 131st Meeting of Council—the first proxy-Council meeting in Adelaide since the transfer—was held on Tuesday, 12th May, 1953.

Present

Dr. A. R. Callaghan (President, in the Chair); Dr. T. J. Marshall (Q'ld); Mr. G. M. E. Mayo (Vic.); Dr. H. G. Andrewartha (A.C.T.); Mr. H. K. Kemp (Tas.); Mr. D. S. Riceman (S.A.); Mr. N. R. McKeown (W.A.); Mr. T. T. Colquhoun (Hon. General Treasurer and proxy for N.S.W.) and Mr. H. P. C. Trumble (Hon. Gen. Secretary).

Business was dealt with as follows:

Arrears of Subscriptions

The Treasurer reported an improvement in the position as indicated to the previous Council meeting (24th March, 1953). Since that date, 143 Corporate and 24 Student subscriptions in arrears had been collected, but there still remained 252 Corporate and 123 Student subscriptions in arrears. The amount still owing on this account was £509/5/0. The need for continued action to collect these arrears was emphasised.

Joint Session with Section K, A.N.Z.A.A.S.

This has now been agreed upon and a joint approach has been made to the Australian F.A.O. Committee to invite Dr. Wahlen, Director-General of the Agricultural Section of F.A.O., to be guest speaker. It is expected that, if Dr. Wahlen is able to accept this invitation, arrangements will be made for him to address Branches of the Institute.

Scientific Representation on the Commonwealth Public Service Board

Council endorsed the action which had been taken by Dr. H. C. Forster (the Institute's representative on the Joint Standing Committee of Professional Scientific Bodies) in consultation by correspondence with the Secretary and principal delegates. The A.I.A.S. associated itself with other professional bodies in an approach to the Prime Minister for the appointment of a scientific member to the Commonwealth Public Service Board. The case was based on needs and overseas precedents.

Journal Advertising

A recommendation from the Publications Committee was received to the effect that a paid advertising representative be appointed. A representative had been located who is prepared to act in such a fashion that commission is payable only in respect of new advertising matter obtained and on renewals of old advertising. Council agreed to this action being taken.

Reports from Branches indicated that considerable effort had been put into attempts to secure advertisements with little success to date. Those Branches which have made only limited efforts so far indicated that they would be devoting more energy to this problem.

Financial Statement

The principal feature of this statement was the presentation for payment of travelling expenses to delegates to the March Council-in-person meeting. Lack of funds had caused deferment of these reimbursements till this late date, which meant that delegates had had to carry the expense from their own pockets.

Council deplored this situation in which delegates and the Treasurer had been placed, and felt that the Institute had an obligation to these officers who were conducting its business. The situation arose largely as a result of the greatly excessive amount of subscriptions in arrears.

Membership

Admissions.

With the recommendation of the Branch submitting the application and of the Qualifications Committee, the following applications were approved for **Corporate Membership:**

Bromfield, Dr. S. M.	Australian Capital Territory
Johanson, R.	,,
Begg, J. E.	New South Wales
Crofts, F. C.	,,
Mears, A. D.	,,
Philpotts, Miss H.	,,
Brett, B. B.	Queensland
Brett, C. S.	,,
Grimmett, S. G.	,,
Horne, W. R.	,,
Letchford, J. M.	,,
Weerawickrema, S. K. A.	,,
Aberdeen, I. C.	Victoria
Chapman, A. L.	,,
Cockroft, B.	,,
Paddick, R. G.	,,
Stanhope, W. C.	,,
Truscott, J. B.	,,
Bainbridge, E. P.	Western Australia
Carlin, B. F.	,,
Dilkes, S. L.	,,
Frith, J. L.	,,
Gaffney, L. U.	,,
Gooding, C. D.	,,
Hale, C. R.	,,

Hobbs, A. W. F. .... Western Australia
Johnston, D. A. W. .... „
Kuneman, F. A. . . . „
Lawson, J. L. .... „
Mann, P. P. .... „
Ralph, C. M. .... „
Schapper, H. P. .... „
Shaw, G. D. .... „
Stoneman, T. C. .... „
Stott, I. K. .... „
Suijdendorp, H. . . . „
Wilcox, D. G. .... „
Wolff, D. R. .... „
Woodward, R. G. .. .. „

Corporate Resignations

Carroll, J. G. .... New South Wales
Kerle, W. .... „
Reynolds, T. M. .. .. „

Trumble, H. C. .... South Australia
Ferres, Miss H. M. .... „

Palmer, J. C. .... Western Australia
Williams, V. J. .. .. „

Student Resignations

Cleeve, Miss M. .... Western Australia
Snow, Miss M. .... „

These resignations were accepted with regret by Council.

Subscriptions waived

On the recommendation of the Branch Committee concerned, the subscriptions of the following members were waived for the years indicated:

Connor, Miss J., New South Wales, 1953, 1954.
Lewis, D., New South Wales, 1953.
Meers, A. J., New South Wales, 1953.
Purchase, Miss H., New South Wales, 1953.
Stack, T. N., New South Wales, 1953.
Ferres, Miss H. M., South Australia, 1951, 1952.
Holloway, Dr. B. W., South Australia, 1952.
Powrie, J. K., South Australia, 1952.
Quirke, Dr. J. P., South Australia, 1951, 1952.
Coleman, R. G., Western Australia, 1951, 1952.

Transfers

Carter, M. V., Australian Capital Territory to South Australia.
Hely, F. W., New South Wales to Australian Capital Territory.
Allen, J. M., Western Australia to Victoria.
Pearce, G. R., Western Australia to Victoria.

Cancellations—Student membership

Gardiner, B. S. .... New South Wales
Sommer, Miss K. .... „

Hayman, D. L. .... South Australia
Jeffries, B. C. . .. . „
Lines, G. .... „ (from 1950)
Linklater, P. M. . .... „
Muhummad, A. M. .... „ (from 1951)
Richardson, J. M. .... „ (from 1951)
Richter, L. K. .... „ (from 1950)
Tideman, A. F. . „
Waterhouse, E. J. . . . „
Yahya, M. U. .... „

Chapman, A. L. .... Victoria
Paddick, R. G. . . .. „

Barrett-Lennard, I. P. .. .... Western Australia
Carlin, B. F. .... „
Chao, L. .... „
Cole, K. S. .... „
Fischer, D. P. .... „
Frith, J. L. .... „
Fry, D. J. .. . . „
Gaffney, L. J. .... „
Grasby, J. C. . .. . „
Hale, C. R. .... „
Hawson, M. .... „
Hedges, D. L. .... „
Hobbs, A. W. E. .... „
Johnstone, D. A. W. . . „
Keightley, G. .. .. „
Lawson, J. A. .... „
Lyneham, A. J. E. .. .. „
Mann, P. I. .... „
Ralph, C. M. .. .. „
Silsbury, J. H. .... „
Somers, M. .. .. „
Stoneman, T. C. .... „
Stott, I. K. . .... . „
Suijdendorp, H. . . .. . . „
Truscott, J. B. . .. . „
Wilcox, D. G. .... „
Wolff, D. R. ... . „
Woodward, R. G. .... „

BRANCH NOTES

Australian Capital Territory

The Eighteenth Annual General Meeting of the Branch was held on 30th March, 1953, at the Hotel Wellington. The guest speaker for the occasion was Sir Ronald Fisher, Professor of Genetics of Cambridge University. The meeting, which was attended by nearly 40 members, concluded with a buffet tea.

"Applications of Statistical Methods" was the title of the address given by Sir Ronald Fisher, in which he dealt briefly with the objectives of statistical methods and the development of experimental design to achieve the desired goals.

In a broader sense the development of statistical methods has made a considerable impact upon the world economic structure, particularly

through such methods as the "complete enumeration survey" or the much more precise "sample survey" conducted by competent teams of investigators.

The following members were elected to comprise the Branch Committee for 1953.

President and Principal Delegate ..	C. S. Christian
Vice-President	F. O. Grogan
Hon. Secretary ..	C. A. Neal-Smith
Hon. Treasurer ..	A. Shavitsky
Journal Sub-Editor	T. G. Campbell
Committee Member	R. Milton Moore

New South Wales

At the 18th Annual General Meeting of the Branch, held at the Rural Bank on 27th February, the following office-bearers were elected for 1953:

President	Prof. P. R. McMahon
Vice-President	Dr. K. O. Campbell
Hon. Secretary	Mr. P. G. Valder
Hon. Treasurer	Mr. J. Walker
Committee Members ..	Mr. W. A. Horsley
	Mr. K. R. Green
	Mr. C. H. Macphillamy
Hon. Sub-Editor	Mr. E. G. Hall
Hon. Business Manager	Mr. C. H. Macphillamy

The Presidential Address, entitled "The conditions of increased production in Agriculture," delivered by the retiring President, Dr. K. O. Campbell, is reported elsewhere in this issue.

A Buffet Tea, was held at the Rural Bank prior to the Annual General Meeting. Sixty-three members attended and the action of the Commissioners of the Bank in again making the rooms available was much appreciated.

Dr. K. O. Campbell, Vice-President of the Branch, has been elected by the Committee of Management as Delegate to Council for 1953. Dr. Campbell attended the Council-in-person meeting in Adelaide on 24th March. Dr. R. N. McCulloch has kindly agreed to act as Proxy-Delegate for the Branch.

The main business of the General Meeting held on 1st December, 1952, was an address by Mrs. S. W. Hayter entitled "Notes on Rural Organizations Abroad." Mrs. Hayter is very well known to members and formerly, as Miss Lorna Byrne, worked with the Agricultural Bureau of New South Wales.

In England, where most time was spent, Mrs. Hayter attended a meeting of the Hampshire Branch of the National Farmers' Union where the main business was a protest against the resumption of land and cottages for an airstrip. In the United Kingdom about 60,000 acres are lost annually from rural production to industry, roads, housing schemes, etc.

At a general meeting held on 30th March, 1953, the guest speaker was Mr. J. K. Kelly whose subject was "The Beef Cattle Industry of Northern Australia." Mr. Kelly is an acknowledged authority on the industry, and, during the years 1948-52, he carried out a survey for the Bureau of Agricultural Economics during which he visited nearly every cattle station in the Northern Territory, Kimberleys and North Queensland. His report on this survey of the prospects for stepping up beef production in these areas was recently published by the Bureau. The theme of the speaker's address was the great importance of Northern Australia in relation to Australia's beef needs and potential production. In terms of present rate of consumption approximately 500,000 tons of carcase beef was required annually to meet Australia's needs. Average production over the last 10 years has been 537,000 tons. To meet the increasing demands of our rapidly increasing population and the need for an average export surplus of 100,000 tons of beef as a fair contribution to our export income, a production in excess of 700,000 will be required in 10 years' time. Mr. Kelly considered that this could readily be provided by meeting the national obligation to develop and populate the North.

Queensland

The Annual General Meeting was held on March 18. The office bearers elected for 1953 are:

President	Mr. W. W. Bryan
Vice-President	Mr. W. J. S. Sloan
	Mr. P. J. Skerman
Hon. Sec.-Treasurer ..	Mr. B. B. Brett
Hon. Assist. Secretary. Treasurer	Mr. B. R. Champ
Hon. Sub-Editor	Dr. R. F. N. Langdon
Committee Members ..	Mr. G. H. Allen
	Mr. F. Chippendale
	Dr. L. G. Miles

The retiring President (Mr. P. J. Skerman), delivered his presidential address entitled "The Brigalow Country and its Importance to Queensland."

At the April meeting, members were addressed by Mr. S. L. Everist, Botanist, Department of Agriculture and Stock. Mr. Everist, who was a delegate to the Sixth International Grassland Congress held at Pennsylvania State College, U.S.A., in August, 1952, spoke of problems of pasture establishment and utilisation in the U.S.A. and Britain, and illustrated his remarks with colour transparencies.

South Australia

The Annual General Meeting was held on April 10. The office-bearers elected for 1953 are:

President	Mr. D. S. Riceman
Vice-President	Dr. R. N. McCulloch
Federal President (ex officio)	Dr. A. R. Callaghan
Hon. Secretary	Mr. V. K. Lohmeyer
Hon. Treasurer	Mr. A. J. K. Walker
Hon. Sub-Editor	Mr. J. W. Ryan
Committee Members ..	Dr. N. T. Flentje
	Dr. H. Andrewartha
	Mr. N. S. Tiver
	Mr. G. Blackburn

The development of resistance to modern insecticides was the subject of the presidential address delivered by the retiring president of the branch (Dr. R. N. McCulloch), at the annual general meeting.

Dr. McCulloch described instances where the development of resistance was suspected, but concentrated on the development of resistance to DDT by houseflies. This had been well demonstrated in careful and detailed work in the U.S.A., which was described.

The resistance was ascribed to the intensive and continuous use of the insecticide, which led to the evolution of resistant races or strains.

For most garden pests, the application of the insecticide was probably not sufficiently continuous or regular to allow the building up of a resistant population.

Dr. McCulloch described modern methods of fly control on farms with particular reference to the results which had been obtained at Roseworthy Agricultural College.

An interesting address on population genetics by Sir Ronald Fisher was attended by members of the Institute on April 24.

After describing how life expectancy curves were built up and how the reproductive potential of various age groups could be estimated, Sir Ronald showed how these could be combined to predict many characteristics of the community.

There were numerous applications of population genetics, he said—the study of virus and bacterial populations where proper control was difficult, the study of linkage in man, the study of polymorphism in ecology and in the study of blood groups in man.

Sir Ronald then made the inheritance of the RH factor in blood groupings the main theme of the lecture.

He said there were seven recognisable groups, three were common, three less common, and one was extremely rare.

There were two hypotheses as to how they were inherited, one that inheritance was via multiple allelles another via three closely linked genes.

Sir Ronald put the case for the close linkage theory, which was supported by statistics and explained how various crossings between the more common groupings could give rise to the rarer types.

Tasmania

The 17th Annual General Meeting of the Tasmanian Branch was held in Hobart on 20th February. The meeting was well attended, 21 members being present. On completion of the formal business members adjourned to the Imperial Hotel where the annual dinner was held. The dinner was also attended by the Secretary for Agriculture, the secretary of the local branch of the Royal Australian Chemical Institute and Professor Leeper of the Victorian Branch of A.I.A.S.

After the dinner the retiring branch president, Mr. T. D. Raphael, delivered his presidential address "The Berry Fruit Industry—Expansion or Regression?"

Office-bearers elected for 1953 are:

President and Principal Delegate	Prof. H. N. Barber
Vice-President	Mr. D. S. Thompson
Hon. Secretary	Miss E. G. Wingrave
Hon. Treasurer	Mr. J. R. Ward
Journal Sub-Editor	Mr. E. J. Martyn
Publicity Officer	Mr. N. M. Hudson
Committee Members	Mr. F. W. Hicks
	Mr. T. D. Raphael

The 56th General Meeting of the branch was held on April 13th. The Principal Delegate reported to the meeting on matters discussed at the Council and General Meetings in Adelaide. The branch programme for the year was also considered.

Victoria

On 10th April, 1953, an audience of about 200 attended a lecture by Sir Ronald Fisher, Sc.D., F.R.S. The meeting was arranged by the University Extension Committee in collaboration with the Institute and other interested societies. Sir Ronald introduced his lecture on Population Genetics with an account of the origin and growth of this subject and went on to describe in detail the genetic analysis of polymorphic characters under the control of closely-linked, non-allelic genes. He presented data on the incidence in human populations of the factors making up the complex series of antigenic types in the Rh system of blood groupings and gave an account of his genetic rationalization of them.

The Annual General Meeting of the Branch was held on 8th May. The Committee elected for the ensuing year consists of:

President	Mr. R. G. Downes
Vice-President	Mr. L. L. Stubbs
Immediate Past President	Mr. L. R. Hoult
Hon. Secretary	Mr. J. A. Roberts
Hon. Asst. Secretary	Mr. R. O. Kefford
Hon. Treasurer	Mr. W. B. C. Mackie
Hon. Recorder	Miss I. J. Stewart
Hon. Sub-Editor	Mr. H. G. Turner
Committee Members	Mr. R D. Croll
	Dr. I. F. Phipps
	Mr. P. F. Butler
	Mr. B. F. McKeon
Professor of Agriculture (ex officio)	Prof. S. M. Wadham

The retiring President, Mr. L. R. Hoult, delivered his presidential address on "The Role of the Agricultural Scientist in Industry."

Each of the two meetings this year has been preceded by a buffet tea which has performed a valuable social function in bringing members together informally. It is hoped that support for this innovation will continue and justify its regular repetition.

During the past year, the Branch Committee has established a number of Standing Sub-Committees on special subjects. The primary aim in this move has been to encourage members to

take an active part in Institute affairs but it is also desired that members' talents should be utilised as efficiently as possible both in conducting Institute activities and in permanent specialist groups who can advise on the wide range of technical aspects of the profession. The following Sub-Committees and their respective conveners have been nominated:

Rural Extension	Mr. H. R. Dickinson
Agricultural Engineering	Mr. G. H. Vasey
Salaries and Status ..	Mr. L. L. Stubbs
Programme	Mr. P. F. Butler
Undergraduate Affairs	Mr. A. J. Vasey
Agricultural Education	Dr. H. C. Forster
Publicity and Public Relations	Mr. R. A. Boyle
Conservation of City Wastes	Mr. R. O. Kefford
Social	Mr. L. R. Hoult

Western Australia

At a meeting held on 31st October, Professor H. B. Creighton delivered an address on "Some Current Research in Plant Science." Professor Creighton stated that through her secretarial duties for the Botanical Society of America she became acquainted with recent research in many fields of plant science. The fields dealt with in the talk were radio-active isotopes, viruses, the cytology of bacteria, the problems of photosynthesis, weedicides, insecticides, fungicides and growth hormones.

A combined meeting of the Australian Veterinary Association (W.A. Division), the British Medical Association (W.A.), and the Australian Institute of Agricultural Science (W.A. Branch) was held on 13th February. This symposium dealt with the subject of "Viruses."

Mr. K. W. Finlay dealt with the historical and agricultural aspects of virus diseases, Mr. J. E. Peterson spoke on the epidemiology of animal virus diseases, and Dr. E. G. Saint discussed the occurrence of human virus infections.

A lively discussion followed and it was generally felt that more combined meetings of this nature would be of advantage to all associations concerned.

A cocktail party was held on 28th January for the purpose of meeting Dr. A. R. Callaghan, the incoming Federal President for 1953, and to farewell Dr. R. C. Rossiter who was leaving for overseas.

The conference for agricultural scientists held in Perth between 23rd February and 6th March proved to be an outstanding success. The theme of the conference was "Advances in Agriculture" and over 100 papers were submitted by specialists in all branches of agriculture. The proceedings of the conference have been published and should prove of value to a wide circle of readers. A pleasing feature was the attendance of visitors from the eastern States including, Mr. R. R. Pennefather, Mr. F. O. Grogan, and Dr. E. A. Cornish.

The Annual General Meeting was held on 16th April when the following office-bearers for 1953 were elected:

President	Mr. H. G. Cariss
Vice-President	Mr. M. Cullity
Hon. Treasurer	Mr. P. N. Forte
Hon. Secretary	Mr. I. C. Miller
Hon. Asst. Secretary ..	Mr. B. J. Quinlivan
Hon. Sub-Editor	Mr. L. T. Jones
Committee Members ..	Mr. S. T. Smith
	Mr. M. H. Wallace
	Mr. D. J. Fleay
	Mr. E. Munch-Petersen
Hon. Auditors	Dr. L. W. Samuel
	Mr. A. M. Stewart

The business session was followed by a buffet tea and the retiring President, Mr. A. J. Millington, delivered his Presidential address entitled, "A New Philosophy for Agriculturists." The theme of this address was that future agricultural progress was dependent on more money for extension and research.

Past policy suggests a parsimonious attitude by governments towards the work of agricultural scientists. The future philosophy must be that agriculture cannot afford not to contribute to greater expenditure on agricultural research and extension.

PERSONAL NOTES

Australian Capital Territory

Recent promotions of members of the Institute within the Bureau of Agricutural Economics, Department of Commerce and Agriculture, have been *Mr. P. A. Reid*, Assistant Director (Agriculture); *Mr. G. Paul Phillips*, Assistant Director (Economics); *Mr. J. N. Lewis*, Principal Research Officer and *Mr. E. S. Hoffman*, Supervising Research Officer.

Mr. F. W. Hely, Senior Research Officer, CSIRO, Division of Plant Industry, has returned from overseas after a period of three years studying bacteriology, particularly rhizobia, and also the taxonomy of *Medicago* spp. as Farrer Memorial Scholar from the University of Sydney. He spent 2½ years at the University of Wisconsin and several months in Europe mainly in Belgium.

Mr. J. V. Mertin, Senior Research Officer, of the Division of Plant Quarantine, Department of Health, has recently transferred to Canberra from Adelaide.

Mr. I. D. Marshall, of the Department of Microbiology, Australian National University, has transferred from the Victorian Branch.

New South Wales

Mr. A. C. Orman, has recently been appointed Principal Vegetable Agronomist of the Department of Agriculture. This recognises not only Mr. Orman's specialist knowledge and long experience in the Department but also the growing importance of vegetable production in the state.

Miss Alison Kingsland, has returned from studying agricultural economics at Cambridge, she also spent some time teaching in England.

Mr. A. Costin, who was awarded a Services Canteen Fund Trust Scholarship, has returned from studying ecology in the United Kingdom and Europe. He will shortly take up duties as research ecologist with the Victorian Department of Agriculture

The Royal Society of New South Wales has recently announced the award of the James Cook Medal for 1952 to *Professor W. L. Waterhouse*. This medal is awarded annually for outstanding contributions to science and human welfare in and for the Southern Hemisphere. The previous recipients have been *Field-Marshal J. C. Smuts, Professor Bernado A. Houssay, Sir Neil Hamilton Fairley*, renowned for his work in the field of tropical medicine, and *Sir H. McAllister Gregg*, now famous for his observations on rubella.

Queensland

Dr. J. Griffiths Davies, Associate Chief, Division of Plant Industry, CSIRO, has transferred to the Plant and Soils Laboratory, Brisbane, where he will direct the Division's pasture research in the sub-tropics.

Mr. P. J. Skerman, formerly Agricultural Resources Officer of the Bureau of Investigation, Brisbane, has been appointed Senior Lecturer in Agriculture, University of Queensland.

Mr. R. F. N. Langdon, has been awarded the Degree of Doctor of Philosophy in the University of Queensland.

Mr. B. B. Brett, who recently graduated in Agricultural Science at the University of Queensland has been appointed Technical Officer, Division of Plant Industry, CSIRO, and is stationed at the Plant and Soils Laboratory Brisbane.

Mr. L. E. Nichols, Director of Research in the Division of Dairying, Department of Agriculture and Stock, will attend the International Dairy Congress in Holland in June.

Mr. R. B. Morwood, has accepted the position of Plant Pathologist, Department of Agriculture, Fiji.

Mr. R. C. Cannon, of the Queensland Department of Agriculture and Stock recently returned from Hawaii where he investigated pineapple production on behalf of the Queensland pineapple industry.

Mr. N. F. Fox, Agrostologist, Department of Agriculture and Stock, has transferred from Brisbane to initiate pasture research work at the beef cattle research station, "Brian Pastures", near Gayndah.

Mr. K. J. Hutchinson, has resigned from the Department of Agriculture and Stock to take up a lectureship at Roseworthy Agricultural College.

South Australia

Professor H. C. Trumble, Professor of Agronomy at the Waite Institute, has resigned and is in the United States at present.

Mr. A. T. Pugsley, senior agronomist at the Waite Institute, has been appointed director of the newly established Agricultural Research Institute at Wagga Wagga, N.S.W. He will take up the appointment in early July. Mr. Pugsley has been awarded the Farrer Medal for 1953.

Mr. G. M. E. Mayo, plant geneticist at the Waite Institute, has been granted study leave by the University of Adelaide. He will study population genetics under Professor K. Mather at the Birmingham University and will attend the 9th International Congress of Genetics at Bellagio in Italy.

Dr. T. Browning, has been given a grant by the Carnegie Corporation of New York to enable him to visit America before returning to Australia.

Mr. R. F. Passey, biochemist in the Division of Biochemistry and General Nutrition, CSIRO, has received a grant from the National Research Council of Canada to enable him to work at the Institute of Parasitology, Macdonald College, Province of Quebec. He will leave late in July.

Miss Helen Ferris, for many years statistician at the Waite Institute and more recently statistician with the Royal Naval Research School of Tropical Medicine at Singapore, has returned to Adelaide. She has resigned from the Institute and will shortly take up a position in England.

Mr. J. K. Powey, Assistant Plant Nutrition Officer, Division of Biochemistry and General Nutrition, CSIRO, has returned to the Division after a year in Europe.

Tasmania

Mr. I. Geard, has been admitted as a corporate member of the Institute. Mr. Geard, who is a graduate in Agricultural Science from Melbourne University, is at present employed in the Plant Pathology Division of the Tasmanian Department of Agriculture.

The Chief Extension Officer of the Department of Agriculture, *Mr. C. A. Holland*, recently spent a brief period in New Zealand.

Mr. J. R. Rayner, has returned from the mainland where he has been studying at first hand certain aspects of irrigation applicable to Tasmanian conditions.

Victoria

Mr. A. J. McIntyre, of the Commonwealth Bank has transferred to the Sydney Office of the Bank and will be Agricultural Adviser in the Economics Department.

NEWS ITEMS

Dairy Industry Investigation

The Minister for Commerce and Agriculture, the Hon. J. McEwen, has announced the appointment of a three-man dairy industry investigation committee to advise on the Commonwealth guarantee to butter and cheese producers to operate in 1953-1954.

The Committee will consist of Mr. A. A. Fitzgerald, chartered accountant and present chairman of the Commonwealth Grants Commission (chairman), Mr. C. Sheehy, chairman of the Australian Dairy Produce Board, and Mr. H. Clark, of the Bureau of Agricultural Economics, Department of Commerce and Agriculture, and a member of the A.C.T. Branch of the Australian Institute of Agricultural Science.

The Committee will take evidence at public sittings in Sydney and Melbourne from persons directly interested.

Conference of Agricultural Extension Officers

A conference of agricultural extension officers from all States of the Commonwealth will be held at the Waite Institute, Adelaide from the 22nd to 26th June.

The first of its kind, delegates representing the various state Departments of Agriculture, the Department of Commerce and Agriculture, CSIRO and the universities will be present.

It has been arranged following a decision of the Standing Committee on Agriculture after considering the best use of Commonwealth funds provided for extension work and is being organized by the Department of Commerce and Agriculture in co-operation with the South Australian Department of Agriculture.

Aspects of extension work to be considered will include social systems within rural communities, personnel, programme planning, assessing results, etc. It is hoped that the resultant exchange of ideas will lead to an improvement of extension services throughout Australia.

Film on Mastitis

An educational film dealing with the causes, treatment and control of mastitis in dairy cattle has recently been released by the Victorian Department of Agriculture. It was produced by the Department's Film Unit in consultation with the Mastitis Section of CSIRO. It is a 16 mm. colour film with commentary and runs for 25 minutes. It is being shown throughout Victoria by the Department of Agriculture and copies are being made available to other States at cost of reprinting.

Soil Conservation Research Centre for South Australia

A new Soil Conservation Research Centre has been established in South Australia at Wanbi in the heart of the Murray Mallee.

This region is a problem area for agricultural scientists, the 11 in. rainfall and the light textured soils make it an ideal situation for the investigation of agricultural problems in marginal lands.

The 3,500 acre block chosen as the site of the station is itself composed of the worst portions of a number of derelict farms abandoned by the original lessees in the days of sand drift and the depression. The Soil Conservation Branch hopes to develop it into a working unit where the problems of the area can be studied.

Fencing, preliminary stabilisation and reclamation of sand drifted areas, and the collection of suitable plants are some of the early moves which have been made.

F.A.O. Fellow in Australia

Spending six months in Australia as the holder of a F.A.O. Fellowship is Mr. Mario Habit of Chile. A graduate of the University of Chile at Santiago, Mr. Habit since 1949 has been Provincial Agronomist for the Magallanes Province in charge of the extension programme. He is also in charge of the experiment station "Rio de los Ciervos," the most southern station in the world, which specializes in cattle raising, milk production, and pasture experiments.

This Fellowship has been awarded through the F.A.O. expanded programme of technical assistance and is for a period of one year, of which three months have already been spent in the United States of America, six months to be spent in Australia and three months in New Zealand. During his Fellowship Mr. Habit will study pasture management and the management of livestock with special consideration to the utilization of pastures in areas subject to periodic drought. He is also interested in methods for the control of rabbits and other forage destroying rodents.

While in Australia Mr. Habit's headquarters will be with the Division of Plant Industry, CSIRO, Canberra. He will spend two months with the Division and three months with State Departments of Agriculture.

Directory of Australian Research Centres

A Directory of Australian Research Centres has been compiled and published by the CSIRO and is now available free of charge from the Secretary (General Adiminstration), CSIRO, 314 Albert Street, East Melbourne.

It contains useful information on current Australian research in pure science, technology, agriculture, veterinary science and medicine.

It is extensively indexed and includes details of research in progress at the Universities, Commonwealth and State Government establishments and independent research institutions. It also lists names and addresses of senior research personnel.

Dr. O. H. Frankel—Election as Fellow of Royal Society

Dr. O. H. Frankel, Chief of CSIRO's Division of Plant Industry, Canberra, has been elected as a Fellow of the Royal Society.

This high honour recognizes the important contributions made by Dr. Frankel to the theory of plant breeding published in some 35 scientific papers.

Prior to taking up his present post with CSIRO, Dr. Frankel was Director of the Crop Research Division of the DSIR, New Zealand. He had worked with the DSIR since 1929.

He was one of the earliest research workers on genetics in New Zealand and has exerted a strong influence on the development of genetics in that country. His work has been concerned particularly with research on chromosomes in wheat and other plants.

Dr. Frankel and his co-workers at the Wheat Research Institute have accomplished the difficult task of breeding wheats which are suited to the New Zealand environment and yet which combine the desirable properties of high yield and high quality. They have enabled New Zealand farmers to grow premium wheats suitable for high quality breadmaking, whereas previously their wheats produced only low grade biscuit flour.

Dr. C. H. B. Priestley—Award of Sc.D. (Cantab.)

Dr. C. H. B. Priestley, Officer-in-Charge of the CSIRO Section of Meteorological Physics, Highett, Victoria, has been awarded the degree of Doctor of Science of the University of Cambridge for his published research on meteorology.

This research has been concerned with the way in which the atmosphere transfers heat from the tropics to the poles. A better understanding of the processes involved will result in more accurate seasonal forecasting.

BOOK REVIEWS

A COMPARATIVE STUDY OF PISUM, VICIA, LATHYRUS AND LUPINUS VARIETIES GROWN IN BUCKINGHAM SAND IN THE COONAPLYN DOWNS AREA, SOUTH AUSTRALIA

By D. S. RICEMAN and J. K. PORRIE

(*This is C.S.I.R.O. Bulletin No.* 269, (1952), *obtainable free of charge from the Secretary C.S.I.R.O.,* 314 *Albert Street, East Melbourne, C.2. Victoria.*)

Further success in the economic cultivation of poor heath country in the Ninety-mile Plain of South Australia is reported in this Bulletin.

The economic cropping of grain legumes in the area concerned marks a further vital stage in the successful efforts of scientists and farmers to adapt the Coonaplyn Downs for food production.

The tests reported were made in freshly cleared Buckingham sand in an area previously shown to be unsuitable in the virgin state for either crops or pasture. Although trace element supplements and the application of superphosphate render Buckingham sands suitable for permanent pasture, nitrogen deficiencies make cereal crops uneconomic.

The success of the present series of tests demonstrates that manageable and productive crops of grain legumes can, however, be won from these soils.

The area selected for the trial carried mallee and broom bush scrub and was cleared and prepared for seeding by the usual methods. Deficiencies in phosphorus, zinc, and copper were countered by applications of 1½ cwt. of superphosphate per ac., 7 lb. of zinc sulphate per ac. and 7 lb. of copper sulphate per ac.

Many of the species tested grew well, and it is proposed to extend the investigation to additional varieties. The Dun variety of field peas yielded more than 25 bushels of grain per ac.

A WORLD DICTIONARY OF BREEDS, TYPES AND VARIETIES OF LIVESTOCK

By I. L. MASON

(*Commonwealth Bureau of Animal Breeding and Genetics Technical Communication No.* 8, 1952, 272 *pp. Obtainable from the C.A.B. Liaison Officer at* 314 *Albert Street, East Melbourne, C.2. Price* 37/6d.)

This Dictionary, the first of its kind, should clarify many doubts and remove many inconsistencies regarding the nomenclature of breeds, types and varieties of farm livestock.

The first part contains over 4,000 entries giving the various names which have been used within each species (horse, cattle, sheep, pig, goat, ass and buffalo). For each breed it recommends an English name, and at the same time gives the English synonyms and foreign names, and such essential information as place of breeding, breed characters, origin, relationship to other breeds, and etymology of the name.

In the second part, the breed composition of the livestock of as many countries as possible is analysed and tabulated. Complete references to literature on the livestock of each country are appended.

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BOOK REVIEWS

THE QUEENSLAND AGRICULTURAL AND PASTORAL HANDBOOK VOL. III. INSECT PESTS AND DISEASES OF PLANTS

By OFFICERS OF THE DEPARTMENT OF AGRICULTURE AND STOCK

(*Government Printer, Brisbane*, 1951, *2nd Edition*, 560 *pp.*, 15/-).

The first edition of this book was published in 1938 under the joint authorship of Veitch and Simmonds. The new enlarged edition covers a wider range of crop plants and a much more complete list of insect pests and diseases, and control measures have been brought nearer to present-day knowledge. Because of its broad cover the authorship has now been spread over the "Officers of the Department of Agriculture and Stock."

An introductory chapter deals with the general biology of insects and their relatives and of the fungi, bacteria and viruses which are responsible for plant diseases. This is followed in Chapter II by a general account of insecticides, fungicides and cultural control measures. The succeeding chapters deal with the pests and diseases of fruit, agricultural crops and vegetables in that order. The last two chapters cover pests of stored products, animal pests of field and orchard crops and miscellaneous pests of the farm home. Whole chapters are devoted to each of the following—deciduous fruit, citrus, banana, pineapple, cotton, tobacco, potato and tomato, while other fruit crops and vegetables are conveniently grouped for adequate treatment. All crops are handled fully and the vegetable sections have been enhanced by the provision of keys to the field identification of diseases and pests of the tomato, and the pests of cabbages, beans and cucurbits.

The decision to treat *seriatim* the pests and diseases of individual crops, instead of dividing the book into two parts dealing respectively with pests and diseases as in the first edition, makes for a more coherent picture of individual crop hazards. This principle is followed up by including all pests and diseases which affect a crop under that particular crop heading. Where an insect or disease has more than one host this leads to some duplication but in a practical handbook such an arrangement is an advantage.

Delays in arranging for printing have prevented the inclusion of the insecticides such as D. D. recently added to the list of those in field use, but D.D.T. and benzene hexachloride are treated rather fully.

The book is well bound, well illustrated and printed, enhancing the standard set by the first edition. It should find a ready place in the libraries of the farmer, the home gardener, students of agriculture and others seeking information on Queensland, or Australian, pests and diseases.

P. J. SKERMAN.

MAIZE IN THE GREAT HERBALS

By JOHN J. FINAN

(*Chronica Botanica Co., Waltham, Mass., U.S.A.; N. H. Seward, Melbourne*, 1950, 40 *pp.*, $3.00).

Much has been written of maize but this well illustrated little volume takes us on a visit into some previously unexplored territory on the subject—the writings of the 16th and 17th century European herbalists regarding the species, their descriptions of the plant, their illustrations of it and also their opinions on whence it came to Europe.

The book is divided into two parts. In part one the author discusses the texts of the herbals and in part two he deals with the woodcuts with which some of them were illustrated. He then draws together his conclusions as to the types of maize in Europe at the period and the probable origins of these types.

Finan observes that where woodcuts are used they do not always entirely agree with the description in the texts. He points out that herbalists frequently borrowed or copied the woodcuts of their predecessors to illustrate their own volumes. This is not surprising as the preparation of new woodcuts was probably both troublesome and expensive. It is a little surprising however to discover that the herbalists apparently often did not bother to check that the borrowed woodcuts were in agreement with the written descriptions. Much of the texts were also probably copied—in the best classical tradition of the time.

Two distinct types of Maize were described and illustrated by the herbalists, one without proproots and one with proproots. The author speculates on the parts of America from which these two types probably originated. He considers the second type probably came from the Carribean area, being brought to Europe by the Spanish. The first type is more of a problem as nothing like it has ever been found in the Carribean area. Finan considers it similar in type to the Northern Flints. He indicates how such a type could have reached Europe.

L. R. KAVANAGH.

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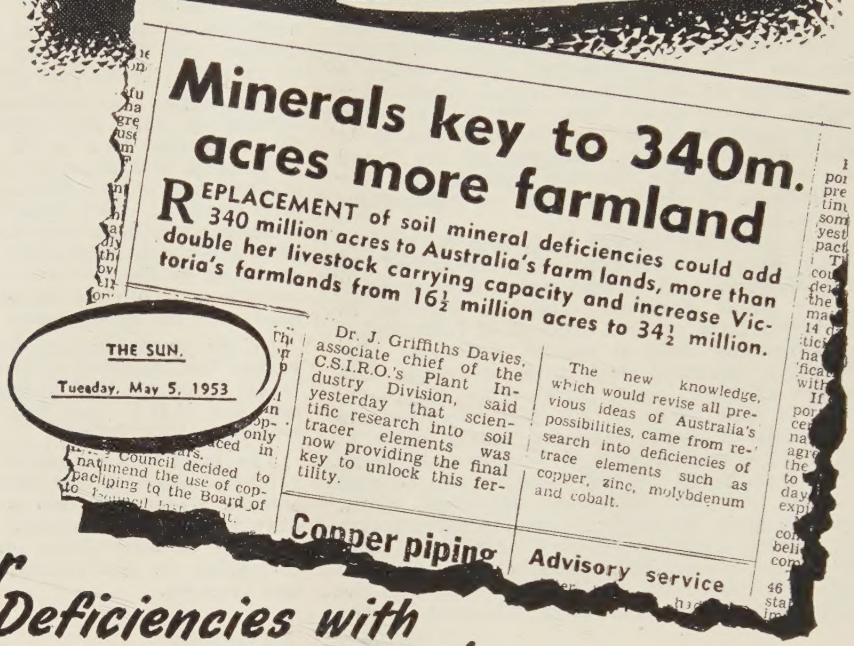

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THE SUN.

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